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Feinstein International Center

Chad, South Sudan and the Sudan

Twin peaks: the seasonality
of acute malnutrition, conflict
and environmental factors

September 2019



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Abbreviations and glossary

ACLED	Armed Conflict Location & Event Data Project
BRACED	Building Resilience and Adapting to Climate Extremes and Disasters
CHIRPS	Climate Hazards Group InfraRed Precipitation with Station Data
CRAM	Community Resilience to Acute Malnutrition
CRED	Centre for Research on the Epidemiology of Disasters
EM-DAT	International Disaster Database (http://www.emdat.be/about)
FAO	Food and Agriculture Organization of the United Nations
GAM	global acute malnutrition
GPS	Global Positioning System
HAZ	height-for-age z-score
IDP	internally displaced person
INGO	international non-governmental organization
IRIN	Integrated Regional Information Networks
MEaSUREs	Making Earth System Data Records for Use in Research Environments
MERRA-2	Modern-Era Retrospective Analysis for Research and Applications, Version 2
MUAC	mid-upper arm circumference
NASA	National Aeronautics and Space Administration
NDVI	normalized difference vegetation index
NGO	non-governmental organization
RCT	randomized controlled trial
SMART	Standardized Monitoring and Assessment of Relief and Transitions
TST	tuberculin skin test
UN	United Nations
UNAMID	United Nations - African Union Mission in Darfur
UNMIS	United Nations Mission in the Sudan
UNSC	United Nations Security Council
VIP	Vegetation Index and Phenology
WAZ	weight-for-age z-score
WHZ	weight-for-height z-score
<i>baggara</i>	cattle herders

<i>deret</i>	end of rains and beginning of the dry season
<i>kharij</i>	rainy season
<i>murhal</i>	livestock migration route
<i>rushash</i>	start of the light rains
<i>seif</i>	hot dry season
<i>shita</i>	cool dry season

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Executive summary

To better understand the resilience and vulnerability of the populations in Chad, the Sudan and South Sudan, the Feinstein International Center, Friedman School of Nutrition Science and Policy at Tufts University has drawn on available secondary data on nutrition, environmental factors (rainfall, temperature and vegetation), conflict and emergency events, together with primary qualitative findings from eastern Chad and western Sudan, prioritizing community perspectives. The report findings underscore the importance of environmental variability and the persistence of climate, conflict and other shocks in relation to livelihood resilience and transformation over time. The findings also challenge long-standing assumptions about the seasonality of malnutrition and present new findings on livelihoods in countries struggling with or seeking to recover from climate, conflict and other disasters.

Many humanitarian programmes have been in continuous operation in eastern Chad, Darfur and Bahr el Ghazal for over two decades. From a community perspective, the past 50 years have been a series of multiple and overlapping hazardous events, many persisting for years, exacerbating their impact and eroding resilience. At the same time, the region is characterized by environmental variability, including rainfall variability (spatially as well as seasonally, and over years) and ecological diversity. Farming and pastoralist livelihood systems characteristic of the region have co-evolved in response to this environmental variability and have adapted to manage delayed rains and drier spells. However, the long history and protracted nature of many shocks, combined with wider trends, have contributed to pivotal changes and to transformations of these livelihoods, although the dryland farming and pastoralist systems remain central to local livelihoods and the economy. The role of seasonality is further reflected in the observed patterns of different types of conflict.

Our data reveal that the region has continued to suffer from high rates of acute malnutrition over the past 25 years, with seasonal peaks regularly exceeding the emergency threshold of 15 percent. Furthermore, contrary to the assumption that in a unimodal rainfall system the peak of acute malnutrition occurs at the end of the lean season, when food insecurity is at its peak, our data show that there are two peaks of acute malnutrition. The first and larger peak occurs at the end of the dry season. It is followed by a slight improvement in acute malnutrition and then a secondary but smaller peak after the lean season. Drawing on the qualitative community perspectives, our analysis points to the seasonality of livelihood systems linked with environmental variability as the crucial determinants of the twin peaks, through its effects on food security, care and health. The analysis also provides insights into the seasonality of different types of conflict, part of which is also related to seasonality of livelihood activities.

The findings from this study have direct implications for household recovery, resilience and nutrition, and raise specific considerations for data collection, future research, programming and policy.

Introduction

Donors, international organizations and academics increasingly recognize the need for evidence-based decision-making (Spiegel, 2017) and generally agree that to generate knowledge and promote an evidence-based culture require collaborative initiatives between implementing agencies, academics or technical institutions, and donors (Braman, Suarez and Aalst, 2010; McCoy *et al.*, 2008). To that end, the Food and Agriculture Organization of the United Nations (FAO) has commissioned the Feinstein International Center (FIC) to review their existing and ongoing research on livelihood resilience in the context of conflict, climate and other shocks, focusing on the Sila and Ouaddai region in eastern Chad, the Darfur region of the Sudan and Bahr el Ghazal in South Sudan.

Over the past 50 years, a continuous stream of shocks has affected the regions of eastern Chad, western Sudan and northern South Sudan. These shocks include environmental hazards, conflict, and economic crisis and stresses such as livestock diseases and plant pests, which often overlap or persist over time as protracted and complex crises. These dryland regions are familiar with extreme environmental variability such as one-off droughts, frequently followed by flooding the following year (the El Niño and La Niña effect) and periodically compensated for by a good rainfall year. However, the multiple levels and types of conflict affecting the region, combined with long-term economic and demographic trends, have challenged even the most resilient dryland livelihood systems. The Darfur crisis triggered an unprecedented international humanitarian response that is continuing today. For the past five years, government and international actors have been actively seeking ways to shift from humanitarian response to early recovery, prevention and building resilience.

Against this backdrop, acute malnutrition (amongst children under five years of age) across the regions is persistent, meaning that the emergency threshold of 15 percent global acute malnutrition (GAM) is frequently exceeded over many years if not decades (Young and Marshak, 2018). Furthermore, there are regions of the Sudan that are not directly affected by conflict that are also experiencing extremely high rates of malnutrition, for example Kassala Locality in Eastern Sudan (FAO-FSBS CBP, 2018). This raises important questions about the drivers and pathways leading to malnutrition, how they are interrelated, and why these conditions persist over the long term despite the humanitarian and development response.

To answer these questions, the authors draw on 15 years of research in dryland environments on the livelihoods of people affected by conflict using different analytical and methodological approaches. The authors utilize findings from both published and unpublished Feinstein research in these regions, including qualitative interviews, focus groups and findings from evaluations. They combine these findings with new analysis and review of available secondary data, rooted in the current literature. This approach has frequently been applied by Feinstein with a view to informing and influencing policy, programmes, and specific project practices and approaches in this region and more broadly.

In this report, we first review livelihood systems in the Darfur region as an adaptation to extreme environmental variability and a long history of multiple, sometimes overlapping shocks.

Second, we analyse seasonal and long-term trends in conflict, acute malnutrition and environmental variables (precipitation, temperature and vegetation) in eastern Chad, western Sudan and the bordering region of South Sudan. We supplement these findings with locally derived qualitative data. The findings confirm long-term trends of persistently high GAM and reveal two peaks of malnutrition, one prior to the start of the rains and a second, smaller peak at the end of the rainy season. These findings challenge long-held assumptions about the lean season (the peak time of food insecurity) as the peak period of malnutrition. Based on the community perspectives, the report proposes that the twin peaks are a reflection of the seasonality of livelihood systems linked with the variability associated with dryland environments. The analysis also provides insights into the seasonality of different types of conflict. We then explore the implications for assessment, programme design and targeting in conflict and post-conflict settings, and new directions for research and learning.

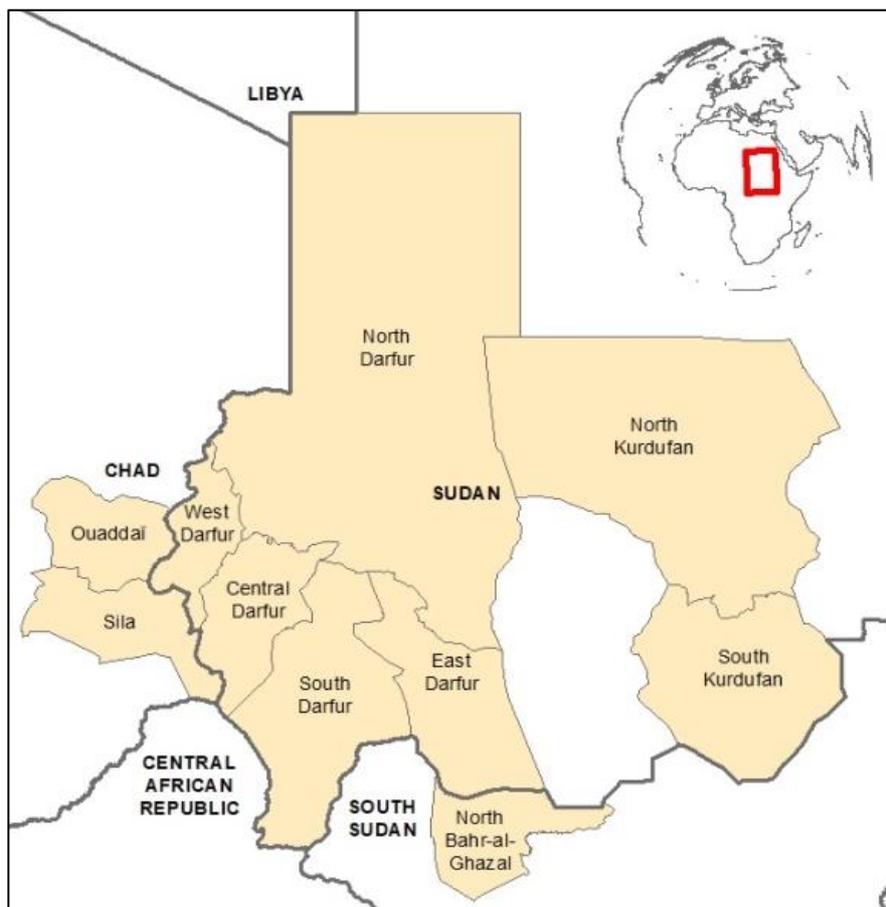
Methodology

The analysis in this report draws on secondary data on nutrition, environmental factors, conflict and emergency events. To further inform the analysis, we combine the secondary data with primary qualitative data from eastern Chad and western Sudan. In this section, we describe each of the data sets and the analysis.

Study area

Our focus for this study is primarily the Darfur region of the Sudan. For comparative purposes, we also include Bahr el Ghazal in South Sudan and Sila and Ouaddai in eastern Chad (Figure 1). This region includes two significant international borders, one between the Sudan and Chad and the other between the Sudan and South Sudan. Harrison and Jackson (1958) classified the vegetation of the Sudan into five ecological categories: desert; northern semi-desert (less than 200 mm annual rainfall); woodland savannah, mostly low rainfall on clay and on sand corresponding to the Sahelian zone; flood region; and montane vegetation.

Figure 1. Map of study area



Source: Feinstein International Center, 2019.

Qualitative studies

This report draws on many of the earlier studies by Feinstein and others in Chad, the Sudan and South Sudan. Feinstein has completed several qualitative studies across multiple communities and has been the operational research partner of three different international non-governmental organization (INGO) consortia and resilience-building programmes in Chad and the Sudan (Taadoud I and 2, Community Resilience to Acute Malnutrition [CRAM], Building Resilience and Adaptation to Climate Extremes and Disasters [BRACED]) over the past eight years. For example, under the most recent BRACED longitudinal study, we conducted two rounds of qualitative investigations in 11 communities across three states: West, North and South Darfur (Young and Ismail, 2019).

Qualitative methods included semi-structured interviews of key informants and focus groups using checklists and participatory response analysis tools. For this paper, we particularly draw on the seasonal calendars and resource mapping completed by women and men, the historical timelines completed by community elders, and the detailed accounts from expert pastoralist herders and rainfed farmers regarding their livelihood specializations, coping responses to wide ranging shocks, and relations with other resource users. These methods were complemented by the global positioning system (GPS) tracking of livestock and were combined with reviewing satellite-based vegetation index and rainfall estimates in three different independent studies (Sulieman and Young, 2019; Young et al, 2016; Young et al 2013).

Under our recent BRACED programme in the Sudan from 2015 to 2017, for example, we completed a total of 71 focus groups (35 with women), 69 key informant meetings and 21 household case-study interviews. With GPS tracking devices, we tracked livestock herds (sheep, cattle and camel) of 13 livestock keepers for six months, from April to September 2017 (with readings every 30 minutes, 24 hours per day). In neighboring eastern Chad, we have completed several rounds of qualitative field studies from 2010 to 2017 (February 2013, March 2013, November 2015, May 2016 and October 2017) under CRAM and BRACED.

Quantitative data management

The secondary data used in this analysis include:

- Standardized Monitoring and Assessment of Relief and Transitions (SMART) surveys
- Environmental variables on precipitation, temperature, and the normalized difference vegetation index (NDVI)
- Armed Conflict Location & Event Data (ACLED)
- The International Disaster Database (EM-DAT).

Nutrition data

Given the lack of consistent longitudinal information on nutrition indicators in our region of interest, we relied on a database of nutritional anthropometry survey data sets. The database was originally compiled by Save the Children in 2007 and then combined in 2015 with an additional database created by the Community-based Management of Acute Malnutrition Forum and Action Against Hunger (ACF). The final database had nutrition data across 55 different countries (Myatt *et al.*, 2018). All surveys used the 30-by-30 nutrition anthropometry survey design as standard per SMART methodology (UNICEF and USAID, 2006).

Table 1. Sample size by country

Country	Individual observations	Surveys	Year range
Chad	79 781	115	1994–2014
The Sudan	60 174	71	2003–2015
South Sudan	120 816	164	1993–2014

From the nutrition data set described above, we extracted information from the three countries of interest for this analysis – Chad, the Sudan and South Sudan (Table 1) – for a total of 350 surveys and 260 771 individual child observations. The data set included the following variables: weight, height, mid-upper arm circumference (MUAC), age (in months), height-for-age z-score (HAZ), weight-for-age z-score (WAZ), weight-for-height z-score (WHZ), gender, administrative region, country and the name of the organization involved in the collection of the data. Outliers (z-score greater than 5 or less than –5) were removed. In addition, a mean value for each of the z-scores and prevalence of wasting, stunting and underweight was calculated for each survey.

Disaster data

For information on the experience of disasters in our region of interest, we relied on the publicly available International Disaster Database (EM-DAT), which is maintained by the Centre for Research on the Epidemiology of Disasters (CRED) at the Catholic University of Louvain (<http://www.emdat.be/>). Information on the type of disaster and its timing is compiled from various sources, such as United Nations (UN) agencies, non-governmental organizations (NGOs), insurance companies, research institutions and press agencies. According to EM-DAT, a disaster is a natural situation or event that overwhelms local capacity and/or necessitates a request for external assistance. Specifically, to be included in the database, an event must meet at least one of the following criteria:

- Ten or more people are reported killed.
- One hundred or more people are reported affected.
- A state or emergency is declared.
- A call for international assistance is issued.

Environmental data

A summary of the data sources and their characteristics is shown in Table 2. The precipitation data derive from the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) data set, version 2 (Funk *et al.*, 2015).

The temperature data utilized in this analysis derives from the National Aeronautics and Space Administration (NASA) Modern-Era Retrospective Analysis for Research and Applications, version 2 (MERRA-2) (Gelaro *et al.*, 2017). MERRA-2 precipitation data were also compared to CHIRPS precipitation. The NDVI data derive from NASA’s Making Earth System Data Records for Use in Research Environments (MEaSUREs) Vegetation Index and Phenology (VIP) global data set. All analysis was implemented using R and RStudio.

Table 2. Data sources and properties for environmental variables

Data source	Reference	Variable(s)	Spatial resolution	Temporal resolution
CHIRPS 2.0	Funk <i>et al.</i> , 2015	Infrared precipitation	0.05 × 0.05	Monthly
MERRA-2 Land Surface Diagnostics	Gelaro <i>et al.</i> , 2017	Surface temperature of land	0.625 × 0.5	Monthly
NASA MEaSUREs VIP 30	Didan and Barreto, 2016	NDVI	0.05 × 0.05	Monthly

Conflict data

Conflict information utilized in this analysis was derived from the most recent release of the ACLED Project (Raleigh *et al.*, 2010). Downloaded data were first categorised according to the regions of interest. Next, the sources of these reports were harmonised by correcting for spelling and acronyms, to produce graphs of media-reporting diversity across study regions. ACLED data were then screened for events categorised as “violence against civilians” and then filtered by the keywords “herder,” “pastoral” and “farmer” in the actor description fields or the event notes. This subset was used to analyse the frequency and distribution of farmer–herder conflicts.

Analysis

In this report, we primarily focus on the ten regions of interest for the study:

- Sila and Ouddai in Chad
- North Darfur, West Darfur, South Darfur, East Darfur, Central Darfur, North Kordofan and South Kordofan in the Sudan
- Bahr El Ghazal in South Sudan

We present findings on the above regions aggregated by country (with some disaggregation for the environmental variables by region). Where the analysis focuses on seasonality, we aggregate the data by month. However, given the small number of nutrition surveys in the key regions of interest (Table 3), we expand both the nutrition seasonality analysis and the combined regression analysis to include all regions in the country.

Table 3. Summary of nutrition data by country for regions of interest

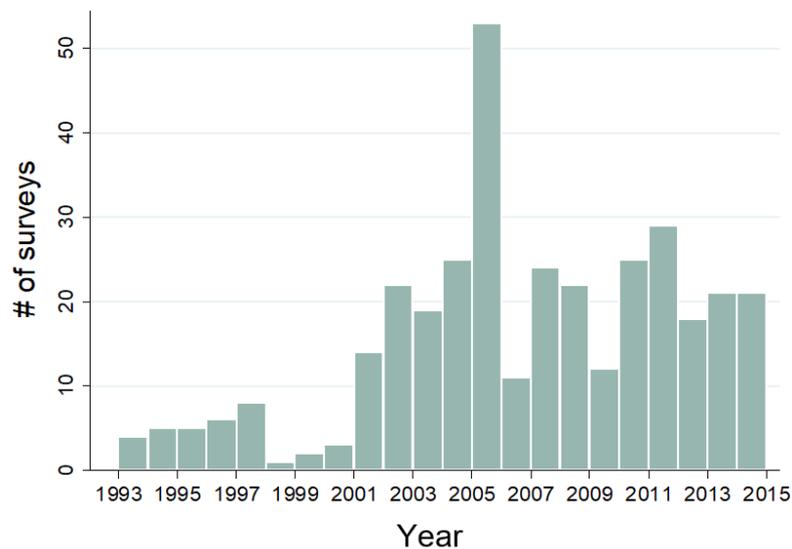
Country	Individual observations	Surveys	Year range
Chad	16 854	25	2005–2014
The Sudan	51 577	58	2003–2015
South Sudan	37 369	54	1995–2014

To combine the data together, we first aggregated the conflict, environment and disaster data set by the largest administrative area below country level present in the nutrition survey (see the ten regions of interest above). Unlike the seasonality of nutrition analysis, here we look at the relationship of all four data sets (conflict, precipitation, temperature and NDVI) across the almost 20 years of available nutrition data for the respective regions. Given the inconsistency of the information on enumerator area in the nutrition data, we had to aggregate to Bahr El Ghazal more generally for South Sudan, rather than only pulling data for Northern Bahr El Ghazal. Similarly, in the Sudan, we had to aggregate to the Kordofan level, rather than being able to distinguish between North and South. It is also worth noting that the use of North, South and West Darfur covers the entire region of Darfur and is based on the administrative areas before they further split into Central and East Darfur (in January 2012). Following the administrative split, we have no full survey data for either Central or East Darfur, and thus this aggregation does not present a problem. All data were then transformed to monthly observations and merged together by region, year and month. For the seasonality analysis, we used GAM as the main outcome indicator; and for the regression analysis, we used both mean WHZ and GAM.

Limitations

These data and the methodology used to draw the conclusions presented in the report suffer limitations that need to be considered when interpreting the results. The malnutrition data are drawn from 350 available cross-sectional SMART surveys, which are highly skewed towards more recent years (Figure 2), biased towards emergency years and locations (given the intended purpose of SMART surveys), provided by organizations on a voluntary basis, and not meant to be representative at any administrative level. Thus, this data should be treated as “found data” and as suffering from selection bias (Myatt *et al.*, 2018). For the seasonality analysis, some of the limitations are compensated for by aggregating data by month and country across the 350 surveys for Chad, the Sudan and South Sudan. Similarly, in the combined analysis we are only seeking to identify correlation without any claims towards causation. However, the selection bias is particularly problematic for drawing any robust conclusions about long-term trends.

Figure 2. Number of SMART surveys by year in Chad, the Sudan and South Sudan



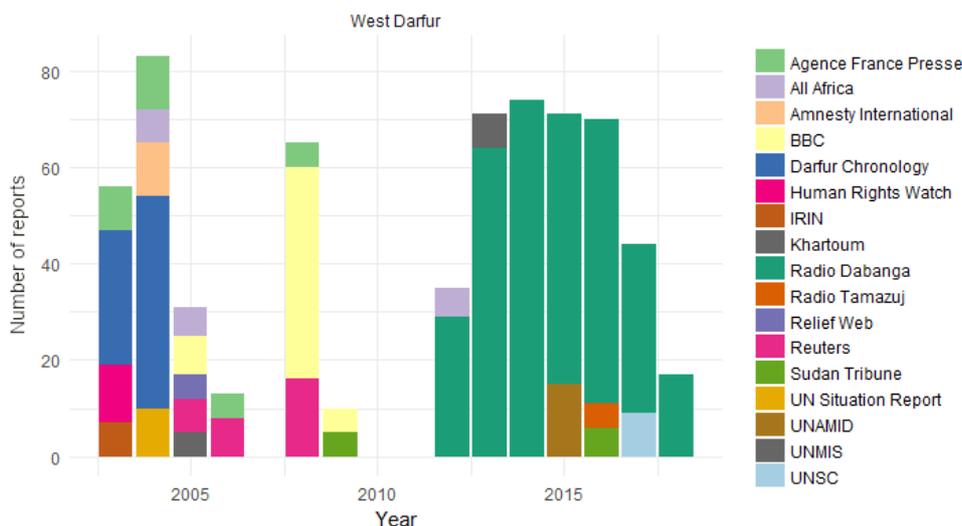
Source: Feinstein International Center, 2019.

The ACLED data source their information from multiple media outlets and thus are subject to the biases of those sources, such as selective reporting or omission. Previous studies of media monitoring have found some geographical bias (Barranco and Wisler, 1999), potentially resulting in a strong “urban bias” in conflict reporting. Kalyvas (2004) argues that conflict reporting is inherently biased towards urban settings because security concerns force observers to cluster at urban sites, with little access to non-urban areas. A review carried out by ACLED shows that there is some urban bias, but it varies by source. For example, only 20 percent of events reported by government or UN agencies are from urban areas, compared to 40 percent of events reported by NGOs and the media.¹

¹ <https://www.crisis.acleddata.com/urban-bias-in-media-reporting/>.

Establishing long-term trends in the ACLED data is problematic, as the reporting sources have changed over time, and the number of media outlets reporting in each region has increased. West Darfur offers an interesting example, in that the coverage of traditional international media sources such as BBC, Agence France Presse and Human Rights Watch has diminished since 2010. This gap has been filled by local media sources such as Radio Dabanga and All Africa (Figure 3).

Figure 3. Sources of news reports in ACLED, West Darfur



Source: Feinstein International Center, 2019.

The analysis of the long-term decadal trends in the environment variables from 1980 to the present should be interpreted with caution. We know from previous analysis that much of the “greening” or increase in precipitation observed during the last three decades is a shift following the droughts of the 1970s and 1980s. In addition, all data were analysed at the monthly scale, which can mask daily and weekly trends in precipitation, temperature and NDVI.

Finally, the aggregation of all four independent sources of data required us to use the highest (non-country) administrative level to allow us to merge the data. This aggregation can further mask internal variations that we know exist from the qualitative data and regional analysis within the regions, particularly in the case of Bahr El Ghazal and Kordofan.

Findings

In this section, we present the results of the seasonality analysis for our environment, livelihoods, disaster, conflict and nutrition data. We end the section by combining all the data sets to look at correlation over time.

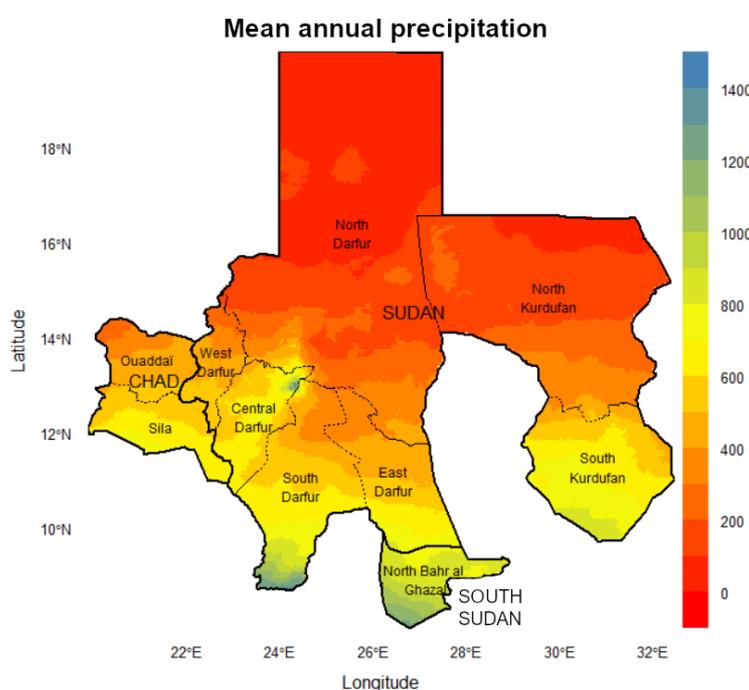
Environmental variability

Variability is a defining trait of all three environmental indicators reviewed for this report: precipitation, temperature and NDVI. All three environmental variables varied across the different regions and within regions over time (seasonally, between years and over decades). In addition, we include information regarding the local perspectives on seasonality (coming out of the qualitative work in Darfur). In this section, we primarily focus on seasonal and spatial variation in the environmental variables, but some information on “long-term” (meaning 1980 through 2018) trends is presented in Annex 1.

Precipitation

The area is characterized by extreme variability across time and space, a single rainy season, and a distinctive rainfall gradient whereby the average annual rainfall increases from south to north (Figure 4), for example from 700–800 mm on the South Sudan border to less than 150 mm in areas of North Darfur and North Kordofan bordering the Sahara desert.

Figure 4. Mean annual precipitation (mm) for study regions in Chad, the Sudan and South Sudan



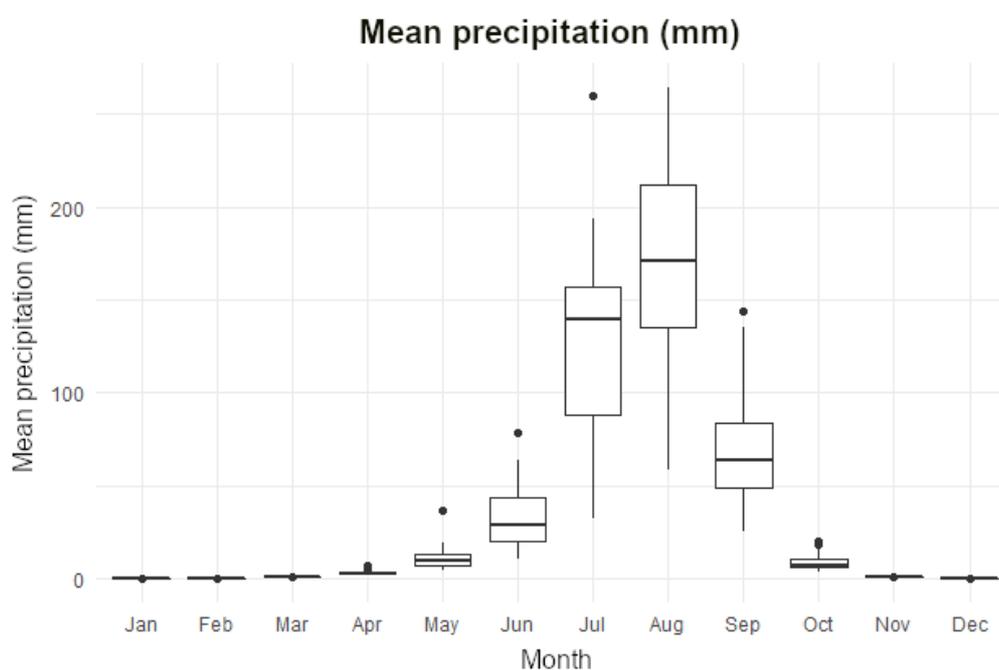
Source: Feinstein International Center, 2019.

In some areas, the precipitation gradient appears extremely stark. For example, precipitation ranges from about 600 mm in El Geneina in West Darfur to about 300 mm or less in Kulbus, West Darfur. These areas are only 110 km apart.

Within a rainy season, there may be prolonged dry spells in some areas compared to others, and these may contradict the rainfall gradient. In addition, within an area, some farms may receive sufficient rains while others do not (which is a rationale for cultivating multiple dispersed fields). The spatial variation in rainfall is the main factor affecting vegetation growth and land use.

Rainfall variability is reflected in both the date of the start of the rainy season and the cumulative amount of rain observed by month. The onset of the rains varies, starting first in the south and slowly progressing north. However, even within the same locale, the start date can vary wildly. For example, in the Ouaddai Region of Chad, the beginning of the rains can start as early as March or as late as June. Figure 5 shows the inter-annual variability in precipitation and the difficulty in identifying the start of the rainy season.

Figure 5. Mean precipitation (mm) and anomaly for Ouaddai, Chad (1980–2018)

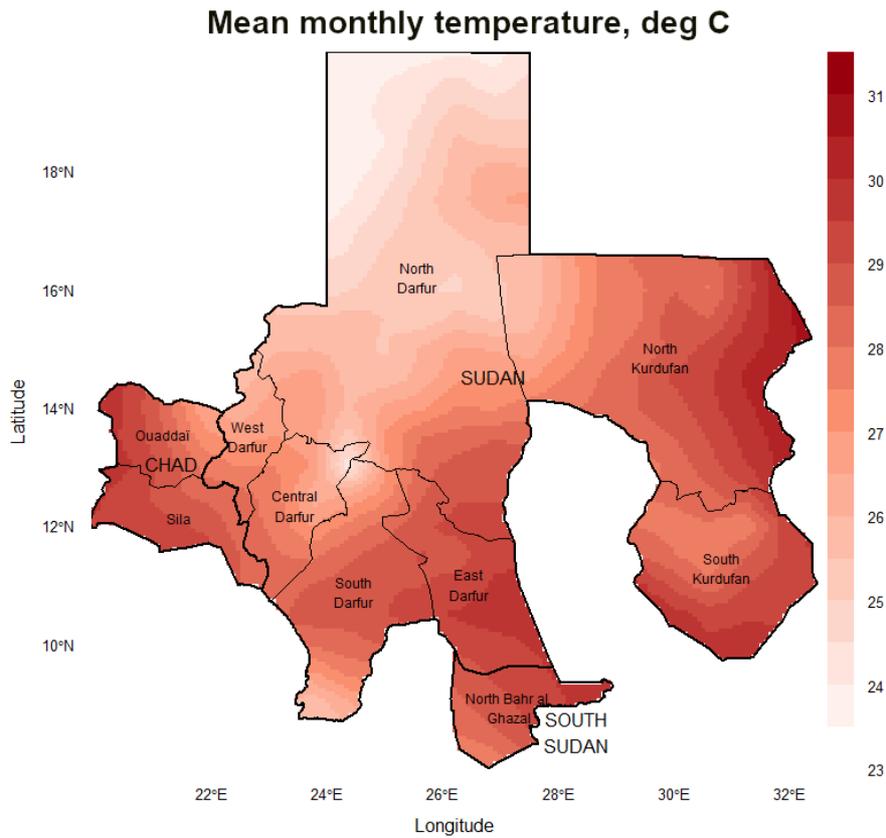


Source: Feinstein International Center, 2019.

Temperature

Similar to rainfall, temperature also presents itself on a gradient in the region (Figure 6). The northern area has lower temperature compared to more southern regions, and compared to the western border of North Kordofan and the eastern border of the regions in Chad. While a gradient in temperature is apparent, it is not nearly as stark as for precipitation, with temperatures throughout the region remaining around 30 degrees Celsius.

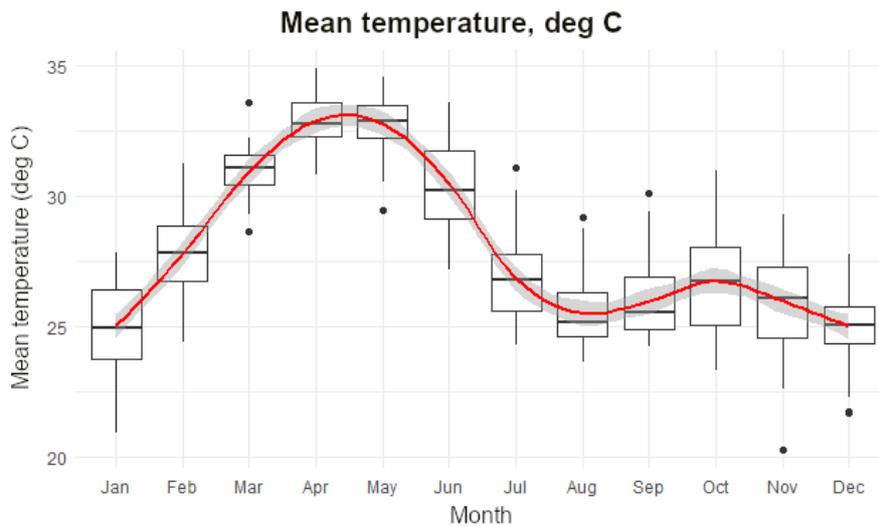
Figure 6. Mean monthly temperature, deg C, 1980–2018 for study regions in Chad, the Sudan and South Sudan



Source: Feinstein International Center, 2019.

Seasonality is clearly apparent in the temperature data as well (Figure 7, example of South Darfur, the Sudan), with the “hot season” presenting right before the rains, dropping off as the rains begin, and increasing throughout the agricultural harvest season when the rains end just before the harvest.

Figure 7. Mean monthly temperature, deg C, (1980–2018), South Darfur, the Sudan

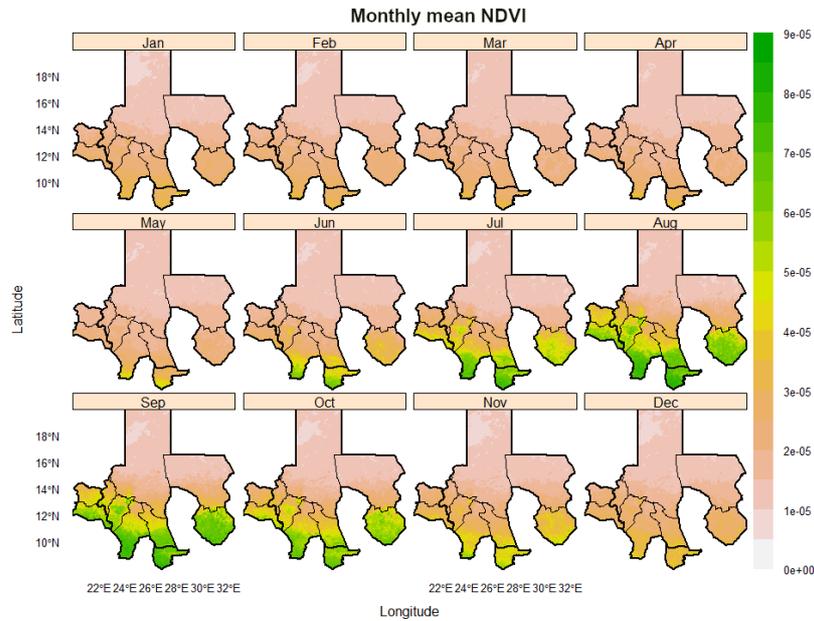


Source: Feinstein International Center, 2019.

Normalized difference vegetation index

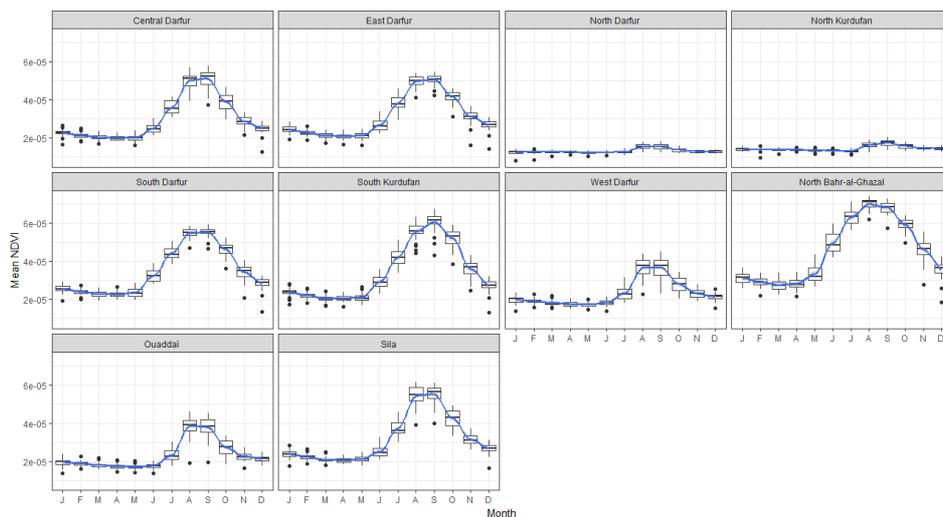
Monthly mean NDVI (from 1981 to 2018) is shown in Figure 8. Since NDVI is a composite index that changes with precipitation and temperature, there is a large degree of variability between months, as seen in Figure 9. The greening corresponds to the start of the rains and follows the same south–north gradient as is observed with precipitation.

Figure 8. Mean monthly NDVI for the study regions (1981–2014)



Source: Feinstein International Center, 2019.

Figure 9. Mean NDVI aggregated (1981–2018) by month for the regions of interest



Source: Feinstein International Center, 2019.

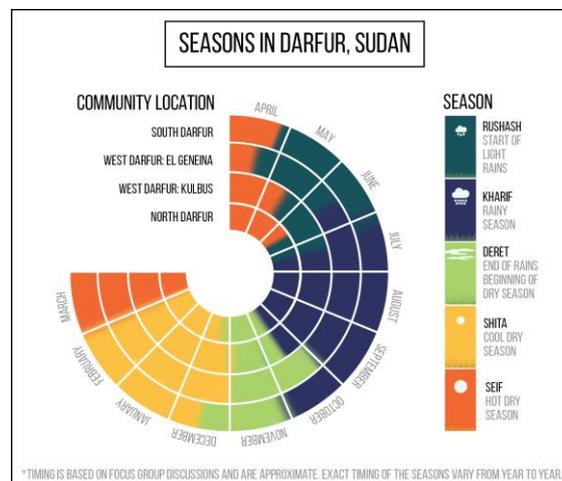
Seasonality from a local perspective

The different seasons as described by local communities (Figure 10, and Table 4) are often far better at conveying seasonal characteristics than the more binary split between rainy and dry season that the international community typically uses in these countries.

In at least four different qualitative studies from 2013 to 2018 in Darfur and Kordofan, the Sudan and eastern Chad, focus groups representing nomadic, agro-pastoralist and farming communities, and women and men identified the same five distinct seasons and their characteristics in detail. The calendar year starts with *rushash*, the end of the hot dry season and beginning of the first light rains, followed by *kharif*, the established rainy season. *Deret* follows after the end of the rains, with reduced humidity and increasing temperatures, allowing crops to mature before harvesting. Next is the cool dry season, *shita*, followed by the hot dry season, *seif*. Figure 10 shows the timing of the seasons by area and illustrates their characteristics (temperature, intensity of rains, cloud cover and condition of vegetation). While some producers emphasized seasonal changes linked to rainfed and dry season cultivation, others described their changing environment in relation to the needs of livestock for pasture, fodder and water, and where these resources could be found (Young and Ismail, 2019).

Seasonal hardships differ by livelihood specialization. For rainfed farmers, the pre-harvest lean season, sometimes referred to as “*deret* hunger,” is when grain stores are low, market prices are high and farmers nervously wait as their crops mature. For pastoralists, the last couple of weeks of the hot dry season (*seif*) and first weeks of the rains, which start as light showers, are particularly challenging. Pasture, fodder and water reserves are limited at the end of the dry season, and livestock are concentrated around permanent water points, which are increasingly congested and overcrowded, with risk of overgrazing in the area. With the first rains, the weather becomes cooler, with intermittent light rains risking spoiling of residues. This occurs at a time when herds are weaker, thinner and potentially more susceptible to infection, and also when green grass is not yet sufficient for grazing. Livestock keepers face heavy workloads at the end of the dry season, watering herds and seeking sources of pasture and fodder. The agricultural work of farmers is also starting, as farmers, often men, have the heavy work of preparing land for planting.

Figure 10. Darfur seasons by locality and approximate month, community perspective



Source: Young and Ismail, 2019.

Table 4. Duration and short description of the seasons of the year in the Darfur region of the Sudan

Season		Approximate duration	Short description – from focus groups
Rainy season (translated as autumn)	<i>Rushash</i>	Mid-May to mid-June	Light rains begin, temperatures rise, wind changes direction. Lack of pasture and water, poor water quality, livestock disease spreads (animals can die). Grasses start to grow and land begins to green, but few pastures. A few birds lay eggs.
	<i>Kharif</i>	Mid-June to end October	Heavier and more established rains. Higher humidity, cool breezes and lower temperatures. Surface drinking water available, birds hatch, some insects appear (mosquitoes), some diseases emerge.
	<i>Deret</i>	October to November	End of rains, increase in temperature, maturation and harvesting of crops. Abundant grazing areas, water available and is of good quality for livestock. Work available, incomes increase.
Dry season (cool) (translated as winter)	<i>Shita</i>	November to February	Temperature drops. Natural water resources dry up, pastures become dry and start to dwindle. Insects disappear.
Dry season (hot) (translated as summer)	<i>Seif</i>	March to mid-May	Hot, sometimes windy and dusty, other times “inactive” or “stagnant” wind. Limited pasture, lack of water for people and livestock.

Livelihood adaptation to environmental variability: the seasonality of specialization

The environmental variability described earlier gives rise to fluctuating harvests (spatially and over time), with some good and some bad years. Partly for this reason, rainfed farmers described an agricultural outlook that spans two or three years or more, rather than focusing on a single season, as they recognize that a bad year might be compensated for by a good year and vice versa (Fitzpatrick *et al.*, 2016; Young and Ismail, 2018). Farmers know that even within a localized area, production can be very uneven, with some farms or fields receiving adequate rain while others may fail.

Similarly, the spatial and temporal distribution of pasture, water and fodder is unpredictable as a result of the extreme variability in rainfall, which pastoralists must manage to the advantage of their herds.

Environmental variability gives rise to highly seasonal and specialist production systems that are adapted to this context. Each specialization has its own well-rehearsed strategies for managing environmental variability and optimizing its production, described in the qualitative studies (see Box 1).

These specialist practices have co-evolved with conditions of environmental variability, meaning that they predate more recent coping responses and livelihood transformations. Young and Ismail (2019) use the term *adaptation* as a noun to signify an existing specialist adaptation to environmental variability, in contrast to the more recent coping responses to a wide range of shocks and wider social, economic and political processes, such as collecting firewood or grasses to sell, or performing casual labour (in construction, trade, agriculture, domestic work, etc.).

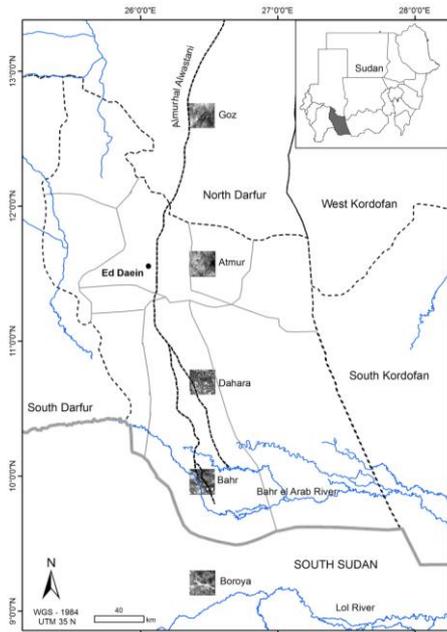
The pastoralist cattle and camel herds migrate seasonally – Figure 11 as an example of cattle migrations. At the start of the rains (*rushash*), the herds are in the south. They move northwards with the advancing rains and greening up of pasture, until they reach the more northern grazing areas where they stay moving around until the end of the rainy season. Their stay further north depends on the availability of water and pastures. Then they return south, where there is more plentiful pasture and fodder and permanent water sources to keep them going through the dry season until the next rains. The pull factor for migration north is the better pasture and breeding conditions for livestock, while at the same time this migration enables herds to avoid the challenges of mud and flies present in the south at this time. This migration north also keeps the animals away from the farms, passing through farming zones without problems, thus reducing risk of crop damage during the agricultural season. The return migration southwards at the end of the rainy season coincides with the post-harvest period, thus allowing pastoralist herds to graze post-harvest crop residues and fertilize farmers' fields. It also allows opportunities for exchange between farmers and herders. However, almost universally, this traditional institution has been undermined, with implications for farmer–herder conflict (see section below, “Seasonality of conflict”). In the past, camel and cattle herds travelled distances of 400 to 600 km between established rainy season grazing areas in the north, connected by livestock migration routes (*murhal*) to dry season grazing areas farther south.

*Box 1. Examples of specialized strategies to manage environmental variability
(Suliman and Young, 2019; Young and Ismail 2019)*

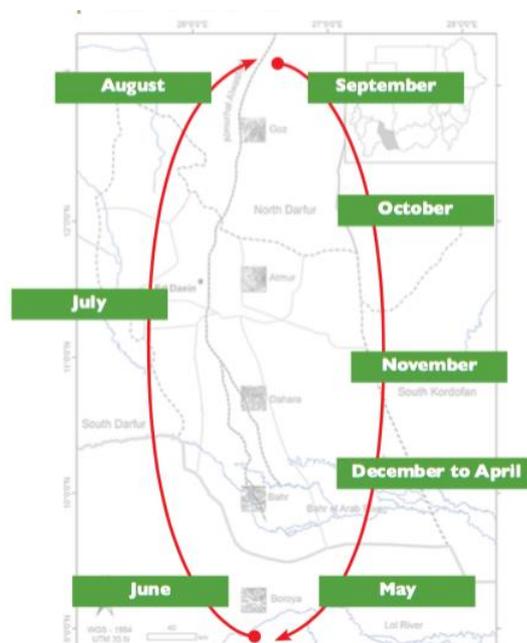
Farming communities recounted their practices for optimizing production given the unpredictability of the rains. Two traditional practices to maintain production are shifting cultivation and distribution of fields so as to reduce risk of rain failure. Currently, shifting cultivation is no longer practiced because of the shortage of cultivable land and changes in land tenure. Hence, farming is now continuous, with no fallow periods and very few, if any, inputs. Crop rotation is commonly practiced, as is diversifying crops over multiple seasons, as well as planting a range of different crops (maize, broad beans, millet and watermelon) to improve soil productivity or improve pest control. Various practices are used to take full advantage of the rains. These practices include: (1) careful monitoring and early cultivation as soon as the soil conditions are damp enough to allow germination; (2) dry seed sowing of millet seeds before the rains start (common farther north and seen as a traditional practice); (3) contouring ridges or barricades to conserve water; (4) multiple repeated plantings if rains are delayed; (5) once seedlings are established, transplanting weaker seedlings in drier areas to fields in areas of better rainfall. In addition, farmers practice experimental plantings in new areas before planting a wider area, so as to compare soils and topography.

Figure 11. Eastern Darfur, showing the migratory routes, approximate dates of movement and an actual example

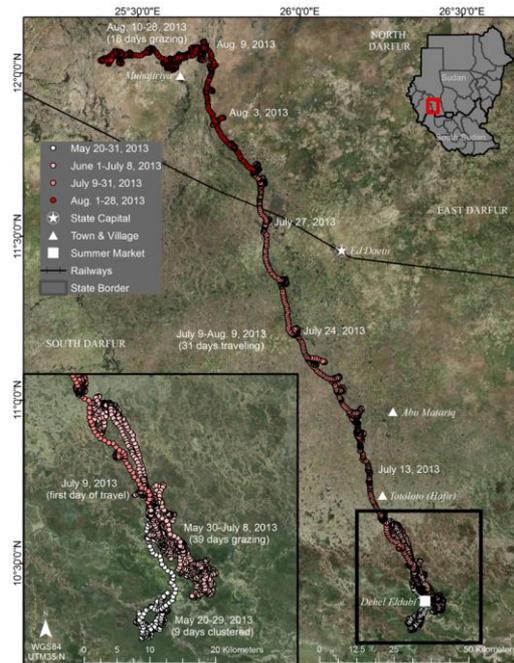
a. Al Wastani corridor



b. Seasonal migration and approximate dates



c. Actual migration of a cattle herd from 20 May to 28 August 2013



Source: Young, Sulieman *et al.*, 2013.

Seasonal cycles of activities

Each livelihood specialization has its own unique seasonal cycle of livelihood activities, with the scheduling of tasks and allocation of time and labour within the season and even on a daily basis driven by the specific climatic and ecological conditions. The inherent uncertainties and unpredictability of rainfall patterns, for example, calls for flexibility. Periods of intense activity are not necessarily the same for pastoralism as they are for farming, as shown in the seasonal calendar (Figure 12).

Amongst these rural communities, their particular livelihood specialization (be it farming or pastoralism) usually takes precedence over other livelihood activities, because these livelihood specializations provide the backbone of their livelihood security, including their food security, cultural identity and way of life. Even when producers diversify, with farmers raising livestock or pastoralists farming, they often do this in order to complement and support their primary specialization. (See also the section on “Coping with continuing risks” below, and “Diversification, coping responses and the long-term transformation of livelihoods” in the Discussion section).

All other livelihood activities are fitted in or around the seasonality of these specialist activities, as shown below. The seasonal calendar distinguishes between the activities of women and men, and young and old, revealing the particularly heavy work burden of women and the more specific dry season activities of young men, who tend to migrate to towns at this time of year. The scheduling of tasks and time for the primary specialization, therefore, exerts a strong influence on the wider pattern of livelihood activities.

The longevity and continued productivity of these farming and pastoralist production systems, in the context of extreme environmental variability combined with a rapidly growing population, are evidence of the systems’ fundamental resilience. However, there are opportunities to further improve and strengthen these traditional systems. Furthermore, these systems are not invulnerable to the never-ending series of environmental, conflict and other shocks they face. At the same time, the systems are being eroded by a wide range of social, economic and political processes, or externalities that are beyond the control of producers. One example is the long-term marginalization of Darfur and the uncondusive policy environment that contributes to this marginalization.

Figure 12. Seasonal calendar of activities by gender of age for Goshosh, Bir Taweel, Goz Deiga, Kulbus Locality, West Darfur

Livelihood Activity	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Notes
	Rushash (start of light rains)		Kharif (rainy season)				Deret (end of rains)	Shita (cool dry season)			Seif (hot dry season)			
Kharif (rainy season) cultivation and harvest of cereals, beans and vegetables	clear land	plant	weed #1	fend cattle off fields			pluck cane, collect crap residues							1
	dry sowing, fertilize				weed #2	cut and pile millet	pile millet							
			pest control				tap millet	gather crops						
							transfer produce from field to home	store produce						
			plant watermelon				harvest kharif watermelon							2
			plant kharif veg				harvest beans, okra							3
Shita (dry season) cultivation							plant shita veg #1	plant shita veg #2	harvest shita vegetables					4
Livestock			Trade livestock products									dig water wells for animals		
												goats and chickens		
												herd cows and sheep		
												horses		
												livestock trade		
Trade (cereals, vegetables, milk, woven products and natural resources)	petty trade millet and peanuts							petty trade millet and peanuts						
	trade						collect natural resources to sell			natural resources			5	
							trade							
Day labour and labour migration	daily labor						daily contract labor							
	brick making									brickmaking				
	manual labor										manual labor			
	mig.										migration			
Legend	Women & Men	Women	Men	Children										

Notes:

1 Millet, sorghum, peanuts; 2 Rainy season watermelon; 3 Rainy season vegetables, beans and okra; 4 Dry season vegetables including okra, chili, tomato, beans, melon, watercress, radish and salad; 5 Firewood, grass, hay and wild foods; 6 Type of trading called *umdawerwer* (traders, usually women, moving between daily markets)

History of shocks and disasters

The Darfur region has a long history of multiple and sometimes overlapping shocks, some of which have led to a series of international humanitarian response programmes. Protracted humanitarian crises and associated programmes have been in continuous operation in eastern Chad, the Darfur region and Bahr el Ghazal for almost two decades. In this section, we present an analysis of the publicly available data on disasters (EM-DAT) and conflict (ACLED) to review trends over time and seasonality. This analysis is complemented by a review of local perspectives on the range of shocks communities have experienced, as determined through community elders recounting the history of environment, conflict and other shocks (from the BRACED programme; see Young and Ismail, 2019).

The range of different shocks experienced by households, including their impact and frequency (from the Taadoud programme; Fitzpatrick *et al.*, 2016) are also taken into account.

History of shocks – a macro perspective

According to the EM-DAT data (not including conflict), disasters are extremely common in the regions of interest covered in this report (Table 5). Over the course of the 22 years of data from 1993 to 2015, Chad experienced 7 years of drought, 4 epidemic outbreaks (primarily cholera), 3 floods and 1 insect infestation. The Sudan reported 4 years of drought, 9 epidemic outbreaks, 11 floods and 1 insect infestation. In South Sudan, 3 years of drought, 7 epidemic outbreaks, and 5 floods were reported. The prevalence of droughts and floods (which usually follow a drought year) is further indicative of the climatic variability experienced in the area, while epidemics are frequently associated with conflict events, displacement and camp settings. Seasonality of disasters was only observed for floods, which consistently happen around the end of the rainy season (September).

Table 5. Disasters in the regions of interest (drought, floods, epidemics, pests) according to EM-DAT

Year	Chad (Sila and Ouaddai)		The Sudan (Darfur and Kordofan)		South Sudan (Bahr El Gazal)	
1993	Drought					
1994			Flood			
1995					Epidemic	Flood
1996						
1997	Drought					
1998			Epidemic	Flood	Epidemic	
1999			Epidemic	Flood		
2000			Drought			
2001	Drought		Drought	Flood		
2002			Epidemic	Flood		
2003						
2004	Epidemic	Insect infestation	Epidemic	Insect infestation		
2005	Epidemic		Epidemic		Epidemic	
2006			Epidemic		Epidemic	
2007			Epidemic	Flood	Epidemic	
2008	Epidemic	Flood			Epidemic	Flood
2009	Drought		Flood		Drought	
2010	Drought	Flood	Flood		Drought	Flood
2011	Epidemic					
2012	Drought	Flood	Drought	Epidemic	Flood	
2013	Drought		Epidemic	Flood	Epidemic	Flood
2014			Flood			
2015			Drought	Flood		
2016						
2017	Epidemic				Drought	

Community perspectives on the shocks they experienced

Community elders from farming and nomadic communities in North, South and West Darfur regions produced historical timelines reflecting on the different shocks that had affected them within their living memory. (For an example from Kulbus Locality in West Darfur, see Table 6.)

Table 6. Historical timeline for Kulbus Locality, West Darfur

Year(s)	Event
1972–1973	The Sugu Famine
1981–1982	Chadian civil wars
1984	Famine – <i>Maga Ammi Nasheelaha</i> (take-your-mother famine)
1988	Severe flood (Goz Deiga)
1990	Drought
1992	Pests – <i>al-Shaw</i> (the red locust)
1995–1999	Tribal conflict
1997	Famine
2000	Conflict (Chadian rebels and government) and displacement
2002	Conflict and displacement
2003	Insurgency
2005	Drought
2006	Cattle theft
2006	Scarcity of rain/drought
2007	Lack of rain and locust attack
2008–2010	Insecurity and road closure
2010	Border threats and increasing risk of livestock damaging crops
2010	Livestock theft
2012	Poor rainy season
2014	Agricultural pests
2015	Floods
2015	Scarcity of rain
2015–2016	Herder–farmer conflict; Chadian herdsmen blocking access to farms

In each community, elders reported a continuous stream of shocks, ranging from drought and floods to conflict (see Box 2), economic shocks, plant pests and livestock epidemics. Their description of conflict episodes revealed that many predated the wider Darfur conflict that started in 2003. Examples of such conflicts include the Chadian civil war and specific tribal conflicts. In the historic timelines, elders did not mention the episodes of farmer–herder conflict over damage to farmers’ fields that affects individual herders and farmers, although this topic was discussed in the individual household interviews as a shock.

Thus, it was considered more of an idiosyncratic shock rather than a covariate one. For most communities, the past 50 years have been a series of hazardous events, some of which have persisted over a number of years, while others overlapped with each other, often multiplying the risks.

Box 2. Community perspectives on conflict

Most communities agreed that the Darfur conflict between the Darfur rebel insurgents and government counter-insurgents from 2003 to 2004 across the region was the most severe and widespread conflict they had experienced in their lifetimes. Some communities experienced armed clashes in their areas that were associated with robbery, looting of livestock, ransacking, and burning and destruction of homesteads. As a result, some communities fled for safety to nearby towns or, in West Darfur, crossed the border into Chad. In both cases, communities ended up in camps for the displaced. Periods of displacement and processes of relocation or return varied widely. Some were prolonged, while others were relatively short, allowing either a quick return or resettlement. The timelines of nomadic communities in North and South Darfur did not refer to this period in the same way, as many were supporting the counter-insurgency. Although some were forced to relocate because of conflict, this was usually to resettle elsewhere and rarely if ever to the displaced camps.

All communities were affected by a range of inter-tribal conflicts over the years. These conflicts often occurred over access to natural resources (whether cultivable land, rangeland or control of traditional gold mining), causing loss of lives and livelihood assets, forced community relocation or displacement (Young and Ismail, 2019).² For example, in 2011, tribal conflicts over control of the traditional gold mining in the Jebel Amer area led to the forced relocation of the nomadic community of El Kother. More recently, in 2016, there were disputes between Chadian camel herders and Darfuri farmers, with armed Chadian herders blocking access to cultivable land and seizing some ploughs.

These community perspectives and historical timelines raised several important issues regarding the severity of a shock and its likely impact across the region. For example:

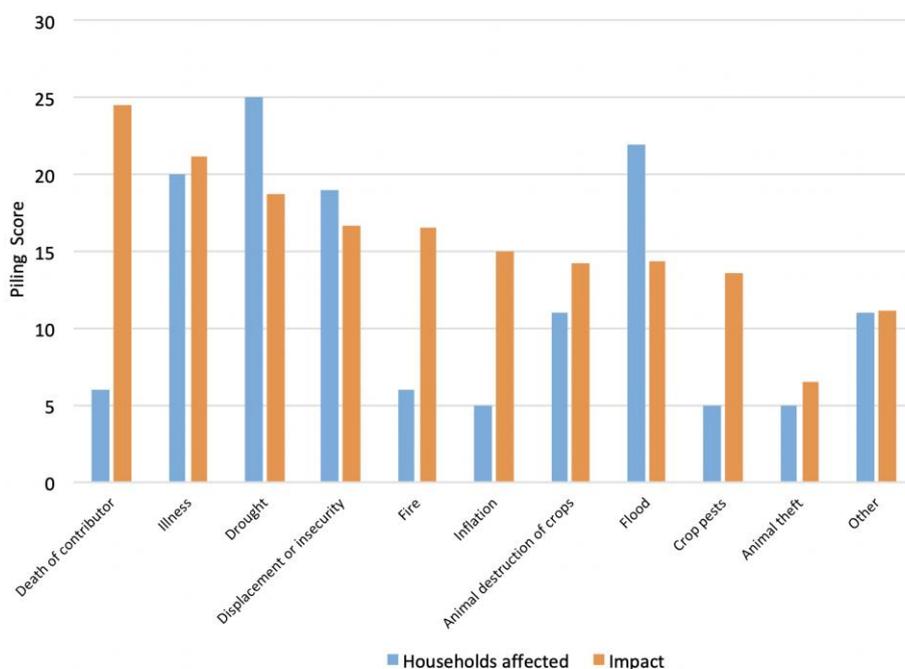
- **Persistence** – One drought is manageable, in part because its impact is almost always patchy and its effects localized. But persistence of drought for two or even three consecutive years exhausts capacities and affects a wider cross-section of the population. Hence, the famines of the 1970s and 1980s, which were particularly dry decades, were the worst in living memory as reported by farmers and nomadic pastoralists in the three states.
- **Combination of shocks** – Combination multiplies the impact of shocks on livelihood systems and affects coping responses. Conflict and drought were combined in 2003, which broadened the scale and impact of the crisis, while widespread insecurity restricted labour migration and access to markets, farms and seasonal pastures. The 1982–1984 famine, an epoch-changing famine across the entire Sahel, was particularly bad for Darfuri *baggara* (cattle herders) because it coincided with a rinderpest epidemic in cattle.

² Displacement tends to refer to the forced displacement of farming communities to internally displaced person (IDP) camps, whereas the conflict-related movement of nomadic communities is rarely described as forced displacement even though it involves involuntary relocation of entire communities, as in the case of many nomadic communities in North Darfur (Young *et al.*, 2009).

From the accounts of community elders, the 1982–1984 droughts marked the beginning of pivotal changes in livelihood systems. For farming communities, this led to migration (displacement in search of aid, increasing labour migration, and for many more-northern agro-pastoralist communities, southwards migration and relocation). For nomads, the changes were less noticeable at the time but equally if not more significant in the longer term. The famines of the early 1970s and 1980s followed each other within a decade, and the 1980s famine was exacerbated by a rinderpest epidemic. While long-distance migration (particularly of camels) saved many livestock, nomads suffered massive losses of cattle, especially in the south. In their accounts, this particular experience of famine was frequently given as the motivation for some nomads to consider alternative livelihood strategies, in part because farmers appeared to recover from these great famines more quickly than nomads did (for example, with the first harvest of 1986 and exceptional harvest of 1988). This prompted some nomadic women in particular to attempt farming activities during the rainy season for the first time, while men continued to move with and manage their pastoralist herds.

The Taadoud studies also confirmed this wide diversity of shocks (Figure 13) experienced by households over the past five years. These studies additionally included idiosyncratic shocks, especially death of a family member and illness, both of which had the same or worse impact on an individual household compared to the most serious covariate shocks. Importantly, households also chose to include animal theft and destruction of crops by migrating pastoralist herds, which were not mentioned specifically in the elders' historic timelines. This was possibly because these were considered idiosyncratic rather than covariate shocks, although they were described as an increasing problem facing communities.

Figure 13. The impact and frequency of shocks by type of shock (among farming households West Darfur)



Source: Fitzpatrick, Young *et al.*, 2016.

Seasonality of conflict

Our analysis of the ACLED data shows that conflicts are highly seasonal, and the peak periods differ according to the type of conflict. While the peak of farmer–herder conflict occurs during the harvest (Figure 14), the peak for all violent events (according to the ACLED data) is in the dry season, with a large increase right after the harvest (Figure 15). Both appear to be linked to the seasonal cycle of farming and herding activities and associated seasonal labour demands.

Figure 14. Farmer–herder conflicts in Darfur states (ACLED data)



Source: Feinstein International Center, 2019.

Farming activities are obviously concentrated just before, during and after the rainy season and correspond to land preparation, planting, weeding and harvest. Herders’ seasonal migrations start in May/June with the first rains and continue up to the cold dry season, when herds are concentrated around permanent water sources, usually in the south. By the time of the hot dry season (April to May), the labour demands for watering and grazing livestock (to avoid the extreme heat of the day and maintain access to sufficient pasture while not exhausting livestock) are at their peak. The peak of violent conflicts in the dry season may also be linked with the ease of movement in the dry season compared with the rainy season constraints of flooded rivers restricting access. The largest proportion of conflict events in the data set from all our regions of interest was concentrated in the Darfur states and South Kordofan.

Figure 15. Number of violent conflict events by month in the regions of interest in Chad, the Sudan and South Sudan (ACLED data)



Source: Feinstein International Center, 2019.

Conflict between farmers and herders as a result of crop damage by livestock is highly seasonal, according to reports from herders and farmers. Conflict is also more common during drought years, when the poor rains have reduced harvest and availability of pasture. In years of poor rains, farmers are more likely to reserve their crop residues for their own use, either as fodder or for building, or to sell a portion to raise cash. Market prices of residues are reported to be higher during a drought year because of the higher demand and lower supply. The ACLED data confirmed this distinct pattern of seasonality of farmer-herder conflict (Figure 13). The data also indicate that the peak problems occur during the harvest season, possibly due to return migration southwards in November during the harvest, thus increasing the risk of crop damage. In drier years, herds may be forced to return earlier due to lack of water farther north, thereby increasing the risk of crop damage and farmer-herder conflict.

Coping with continuing risks

Table 7 describes three categories of coping responses of Darfuri farmers and pastoralists, including agricultural expansion and intensification, diversification and labour migration (from Scoones, 1998), with examples of how each group has introduced changes to their production system in response to the risks they face.

Table 7. Examples of coping responses amongst Darfuri farmers and nomadic pastoralists

	Rainfed farmers	Nomadic pastoralists
Agricultural intensification and expansion	<ul style="list-style-type: none"> From shifting to fixed cultivation Inter-cropping Expansion of dry season irrigated farming Investments in livestock: for men, sheep and cattle; for women, goats and chickens Fencing of fields and rangeland for own use 	<ul style="list-style-type: none"> Changing herd composition from camels and cattle to sheep Changes in migratory patterns Splitting herds – requires extra labour Reduced watering frequency Using concentrates or residues Encouraging night-time grazing
Diversification	<ul style="list-style-type: none"> Collection and sale of forestry resources: fuel, building, charcoal Day labour: agricultural, local construction, domestic, etc. Trading activities, including petty trade by women 	<ul style="list-style-type: none"> Rainfed farming (portion of the household settles to manage the farm) Collection and sale of forestry resources: for fuel, building, and making charcoal Trading activities, including petty trade by women and trading activities involving youth with vehicles Day labour less common
Migration	<ul style="list-style-type: none"> Drought- and famine-induced displacement (1980s) Forced migration and displacement linked to the Darfur conflict Dry season and longer-term labour migration nationally and abroad, mostly men 	<ul style="list-style-type: none"> Relocation of communities farther south in response to conflict Rural urban migration by young men to join military

Farming communities have expanded and intensified their agricultural production to include irrigated agriculture, inter-cropping, dry season irrigated farms and gardens producing cash crops. Dry season agriculture and marketing of the cash crops grown have especially increased, although this depends on household access to suitable land and water for irrigation. There has also been an intensification of land use in the immediate environs of former displaced communities, because of the security risks associated with farming beyond the village boundaries. Farmers explain this has also contributed to shrinking farm size and reduced productivity.

The women from settled nomadic communities of West, North and South Darfur are attempting rainfed farming, but especially in South Darfur, they lack the skills and experience, and frequently rely on paid agricultural labour to work their farms. Pastoralists are also changing the composition of their livestock herds from camel and cattle, which are traditionally favoured, to include sheep,³ which are valued for their quick economic returns in the context of a thriving regional and national market. A Telehaya herder explained that amongst the settled nomads, sheep are preferred “for their quick reproduction, decent prices, ease of herding and not being stolen.” However, sheep are more vulnerable to disease than other livestock and so are the most costly species in terms of medical treatment and timely vaccination (Suliman and Young, 2019).

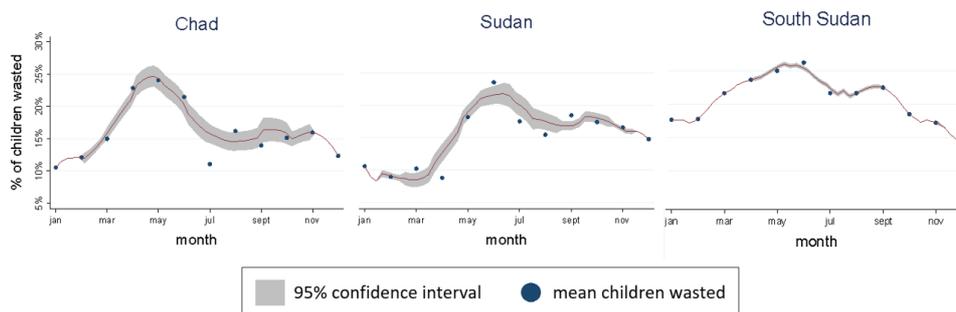
Response capacities have been eroded as a result of a loss of household labour from migration of young and older men, and additional constraints have been added to the well-known climatic ones. In turn, there are several newer forms of diversification, many linked with the emerging war economy and conflict, such as the young men joining the armed forces or militia, or the increased trade linked with servicing the needs of the internally displaced person (IDP) camps. Brickmaking activity was present almost everywhere, with poorer people supplying the labour. The advent of artisanal gold mining in North Darfur acted as a magnet to men from communities across West Darfur as well as North Darfur.

Nutrition

Acute malnutrition (WHZ < -2) and mean WHZ follow a clear seasonal pattern in our three country case studies. However, the seasonal pattern in Figure 16 varies from the long-held assumption that the peak of acute malnutrition corresponds to the peak of food insecurity at the end of the lean season. Instead we observe twin peaks in GAM: one at the start of the rains and another at the end of the rains (the lean season). The peak observed at the start of the rains tends to be larger and is followed by an improvement in population-level child nutritional status before the onset of the second peak.

³ Desert sheep are the most popular, but local breeds adapted to the wetter conditions farther south are also increasing.

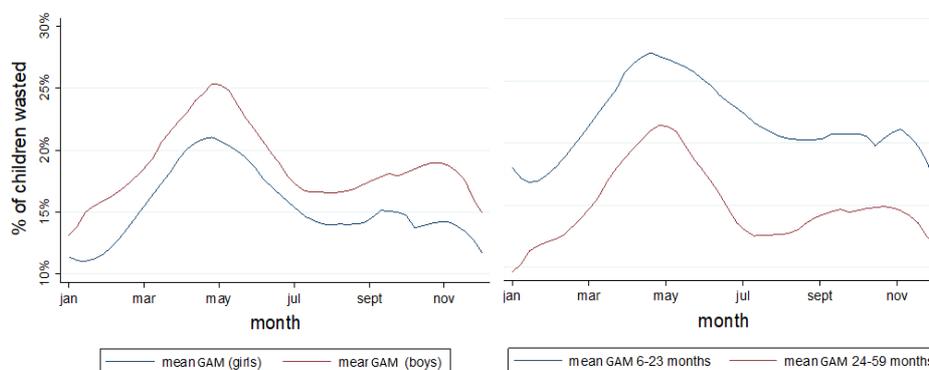
Figure 16. Prevalence of wasting across month (Chad, the Sudan and South Sudan)



Source: Feinstein International Center, 2019.

The seasonal pattern observed for the data from all three countries is replicated when comparing boys versus girls and 6- to 23-month-old children versus 24- to 59-month-old children (Figure 17), suggesting that seasonal drivers of malnutrition are independent of age and gender. While the figures below are just for Chad (to serve as an example), this finding is significant for all three country case studies, with boys and children under the age of 2 being severely more wasted at every time period.

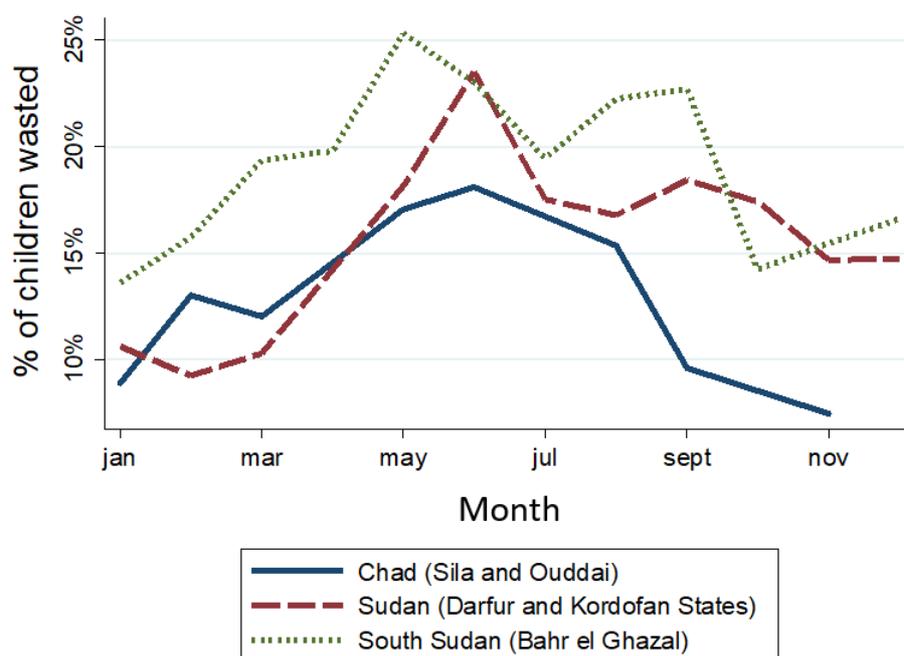
Figure 17. Seasonal analysis by gender and age group in Chad, the Sudan and South Sudan



Source: Feinstein International Center, 2019.

Isolating the data to only the regions of interest (without smoothing), we find a similar pattern, with the distinction that in Sila and Ouaddai the second peak vanishes completely, with only the June peak remaining (Figure 18).

Figure 18. Mean GAM for regions of interest only



Source: Feinstein International Center, 2019.

Combining nutrition, environment, disaster and conflict data

In this section, we combine all our data sets and aggregate them on the level of the nutrition SMART survey (meaning one observation for each data set per survey). As a reminder, this analysis expands beyond the regions of interest and instead utilizes all available data (nutrition, conflict, disaster and environment) for the three countries: Chad, the Sudan and South Sudan.

Table 8. Spearman correlation between the environmental and nutrition variables

		HAZ	WAZ	WHZ	GAM	Stunting	Under-weight
Chad	NDVI	0.23	0.54	0.56	-0.54	-0.19	-0.48
	Precip	0.13	0.04	-0.08	0.13	-0.05	0.01
	Temp	-0.01	-0.21	-0.29	0.31	0.03	0.22
The Sudan	NDVI	-0.15	0.11	0.37	-0.33	0.15	0.01
	Precip	-0.06	-0.15	-0.18	0.20	0.04	0.14
	Temp	-0.02	-0.16	-0.16	0.16	0.08	0.21
South Sudan	NDVI	-0.29	-0.12	0.18	-0.12	0.34	0.19
	Precip	0.03	-0.04	-0.12	0.21	-0.03	0.06
	Temp	0.27	0.12	-0.23	0.22	-0.29	-0.15

Note: Grey box equates to significance at alpha < 0.01.

We started by looking at the correlation between the environmental and nutrition variables (Table 8). While, on the whole, the relationship between the environment and nutrition variables is significant and large, there are distinctions across the three countries. In Chad, the correlation between the environmental variables and nutrition is the largest, with the variability in NDVI explaining over 50 percent of the variability in WAZ, WHZ and GAM (and almost underweight). In the Sudan, the relationship between NDVI and nutrition is limited to WHZ and GAM. In South Sudan, the strongest relationship with NDVI is observed with stunting, which does not exhibit the same seasonality as wasting. Therefore, this observation is harder to explain. A pattern does emerge across all three countries whereby both NDVI and temperature are more likely to be significantly correlated with nutrition outcomes than precipitation. Furthermore, a higher NDVI is consistently correlated with better nutritional status, while a high temperature is correlated with worse nutritional status.

Next, we ran a harmonic regression (meaning accounting for within-year seasonality) on mean survey child WHZ and mean survey child GAM with the following independent variables:

- Monthly mean NDVI by region
- Monthly mean precipitation by region
- Monthly mean temperature by region
- A measure to account for seasonality definitive of a harmonic regression [$\sin(2*\pi*month/12)$ and $\cos(2*\pi*month/12)$]
- Total number of conflict events for the year⁴ by region
- Whether the survey was done in a camp setting
- Whether the survey was done in an urban setting
- A time variable (month and year)
- Total number of drought events for that year by region
- Total number of epidemic events for that year by region
- Total number of flood events for that year by region
- A dummy variable for month (with respect to January).

⁴ None of our specific survey times corresponded with active conflict, so we aggregated all conflict events for that year.

Table 9. Regression analysis on mean WHZ and GAM

	Mean WHZ	GAM
Sin	0.2760***	-0.0367**
Cos	0.1250	0.0031
Precipitation	0.0001	0.0000
NDVI	0.0010***	-0.0001**
Temperature	-0.0003**	0.0001**
Total yearly conflict events	-0.0016**	0.0004**
Camp	-0.0217	0.0135
Town	0.2940**	-0.0824**
Time	0.0012***	-0.0003***
Total drought months in the year	-0.0493	0.0096
Total epidemic months for the year	0.0643	-0.0186*
Total flood months for the year	-0.0381	0.0048
Month (with respect to January)		
February	-0.1792	0.0234
March	-0.2483	0.0563
April	-0.3411	0.1022
May	-0.1785	0.0889
June	-0.1658	0.1009
July	0.1512	0.0307
August	0.1774	0.0159
September	0.1010	0.0187
October	0.1974	-0.0056
November	0.0000	0.0000
December	0.0000	0.0000
Constant	-1.6873	0.3219
R^2	0.3229	0.3290
***significant at p -value < 0.01; **significant at p -value < 0.05; *significant at p -value < 0.1.		

A few key points emerge from the regression analysis (Table 9). First, within-year seasonality has some of the greatest explanatory power in terms of both mean WHZ and GAM prevalence, which is reflected in both the significance of the sine and cosine variables (which define the harmonic nature of the regression) and the pattern in the coefficient of the monthly variables for WHZ. What we find (while not significant) is that in relation to January (when children generally have higher WHZ and lower GAM), WHZ consistently declines (negative coefficient) through June and then actually starts to improve. This corresponds directly to our seasonal nutrition analysis, which identifies May and June as the peak of child wasting.

Second, as with the Spearman correlation above, NDVI and temperature are shown to be significantly correlated with nutritional status, with a higher NDVI associated with better nutritional status and a higher temperature associated with worse nutritional status. From the independent analysis of the environmental variables, we know the highest temperature usually occurs prior to the rainy season, while NDVI improves through the rainy season, thus again highlighting the vulnerability of children prior to the start of the rains rather than during them.

Third, of our shock-related variables, the only variable that is consistently correlated with wasting is conflict. The more conflict events there were in a year, the higher the prevalence of wasting and the lower the mean WHZ. The data from the Darfur region of the Sudan could be driving this relationship, considering both the large number of surveys done in 2005 and the large number of violent events during that period. Experience of droughts, epidemics or floods is not correlated with nutritional status. We also observe that nutrition status in towns (i.e. SMART surveys conducted in urban areas) was significantly better. And, while we accept the limitations of the data set in terms of long-term trends, our time variable is significant, indicating long-term improvement from 1993 to 2015.

Finally, we evaluate the quality of our model by referring to the R^2 value. For both models, our variables explain about one-third the variation in GAM and mean WHZ over time. While still small, this R^2 tends to be higher than the R^2 observed in most nutritional household-level surveys, thus indicating the strong role of the environment and the value of secondary region-wide data as potentially basic causes in understanding patterns and possibly drivers of malnutrition.

Discussion

The environmental variability found in dryland environments (and specifically in our three country case studies) underlines the critical role of seasonality in almost every aspect of life. The role of this seasonality clearly comes out in our secondary data analysis, in relation to the environment, conflict and child acute malnutrition. However, particularly remarkable is that these findings challenge the dominant narrative regarding the seasonality of acute malnutrition and how this is addressed in the Sahel. In this section, we review the findings of our secondary and primary analysis and their implications for programming and policy.

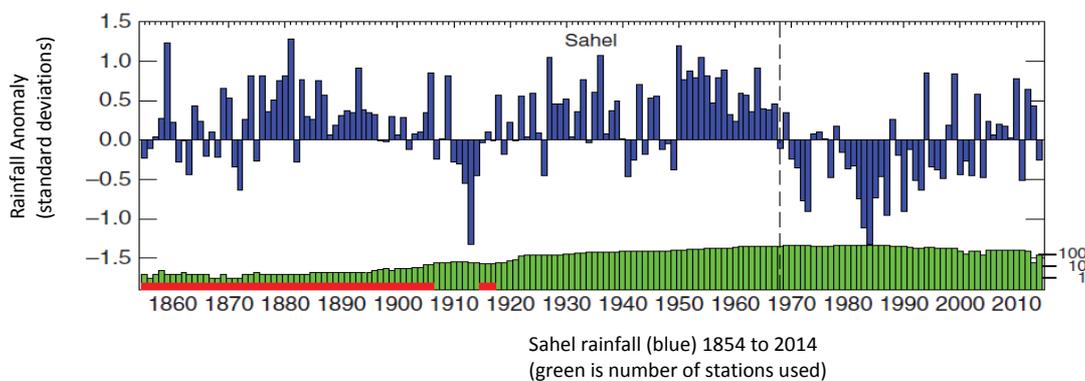
Environmental variability and livelihood adaptation

Sub-Saharan dryland pastoralists and farmers share an ancient history, having co-evolved over centuries following environmental change in the Sahara and sub-Saharan. Archaeologists argue that much can be learned about processes of adaptation in response to climatic changes during the Holocene period (around or soon after 10 ka; Brooks *et al.*, 2005). For example, in Libya two types of response have been identified: highly mobile nomadic pastoralism based on sheep and goats and an alternate response of sedentism in lower elevation regions. The southern edges of the Sahara exhibit the largest variations in rainfall compared to the other regions in our study, and a profound north–south gradient in mean annual rainfall is evident.

This extreme rainfall variability that is characteristic of drylands occurs within years, between years and over decades, producing medium- to long-term trends. Combined with the localized ecological diversity, this rainfall variability influences the seasonal distribution of natural resources (cultivable land, water, pasture and forest) and livelihood productivity. Figure 19 shows the long-term trends in mean annual rainfall for the wider Sahel since 1860.

In our region of interest, the annual rainfall mean has significantly increased since the 1980s. However, this increase was not equally distributed spatially, with some areas experiencing a significant increase, while others showed a decrease in mean rainfall (see Annex 1). The spatial variability in long-term trends was further observed with both temperature and NDVI, which increased on average but not consistently across the region.

Figure 19. Sahel rainfall, 1854 to 2014



Source: Nicholson, Funk and Fink, 2018

The timing of the seasons is the most important factor dictating the overall rhythm of the agricultural and pastoral cycle, while all other livelihood activities must fit around this schedule. There are several aspects to this variability and unpredictability of the rains, including a distinct north–south rainfall gradient, variable start dates for the rainy seasons and, within the rainy season, dry spells or periods of more intense rains. The distribution of rain over time and space is more important than the annual total in relation to agricultural and pastoralist strategies.

Recognition of the extreme rainfall variability and ecological diversity that are characteristic of drylands and their influence on the livelihood practices of dryland communities leads to a very different understanding of the way in which livelihood production systems manage the seasonal constraints and unpredictability facing them. Their strategies are designed to take advantage of opportunities as they arise, while evading seasonal hazards, and with a longer-term outlook on optimizing their production in a context of extreme environmental variability. This is a reflection of their long-term adaptation and in turn the resilience of their production systems in this context. This view of livelihood adaptation and specialization is consistent with the non-equilibrium paradigm (Behnke, Scoones and Kerven, 1993; Scoones, 1996, 2018; Krätli, 2015). It also fits with producer perspectives, which expect both good and bad years. Therefore, their outlook extends beyond a single season to include two or three years or longer in order to allow the better years to compensate for the bad years (a feature of dryland livelihoods also noted by Scoones, 2004).

Adaptation, seasonality and shocks

A focus on the seasonal livelihood patterns and the day-to-day activities and actions of women and men provides a framework for understanding the production specializations as adaptations to environmental variability. A complementary focus on the risks, shocks and constraints facing people and their livelihoods reveals the limits of their specializations and explains the need for adjustments to their specializations or indeed their need to pursue other options to fill the livelihood gap. This study has shown the long history of shocks that are a constant feature of life in these dryland contexts, and the importance of considering both the persistence or duration of shocks and the heightened impacts of combinations of shocks, which is relevant to famine early warning systems.

In addition, studying these seasonal patterns provides a way of identifying specific points where multiple constraints might converge and intensify or where limiting conditions are most apparent, and where consequences of responses might become more heightened and critical (Leatherman, Thomas and Luerssen, 1989). This is particularly relevant to understanding the factors limiting livelihoods or indeed the seasonal drivers of malnutrition. For example, there are particular times within the year when production systems face increasing constraints and pressures. One such time is the hot dry season for pastoralists, when water and pasture are most limited, and livestock are concentrated at nearby permanent water sources. For farmers, the unpredictability of the rains, which might mean delayed rains, dry spells or indeed heavy rains affecting crops, are ever-present and must be managed. Between-year variability can also introduce constraints.

For example, during a drought year at the end of the rainy season, there are particular pressures on both farmers and pastoralists. Pastoralists are pressured to return south early because of lack of water, which increases the risks of livestock damaging crops and consequent conflict with farmers.

Diversification, coping responses and the long-term transformation of livelihoods

In the past 50 years, a wide range of economic, social and political factors have impacted local livelihood systems and their integration. There has been, for example, the commoditization of natural resources and the changing governance landscape, including an increasing plurality of customary and formal laws. Farmers and pastoralists are working within an increasingly commercialized and expanding economy. In this economy, the natural resources they depend upon have an economic value, which increases competition and the risk of conflictual relationships. This has prompted producers to expand and intensify their production and to diversify, where they can, into other forms of primary production. Importantly, the goal of the complementary farming or livestock keeping often differs from the goals of specialist pastoralists or farmers, as the additional primary strategy is intended to support or even enhance the primary livelihood specialization. This has implications for targeting of agricultural interventions, as the requirements of the specialist producer are very different from those of the newcomer to a specific practice (such as nomadic women starting to farm).

Small-scale farmers and herders with fewer livestock or less access to land increasingly must rely more on unreliable day labour; petty trading activities, especially in natural resources; or labour migration to meet their household needs. The constraints facing them mean that production processes change. For example, livestock migrations are shorter, allowing more flexibility in organizing household labour. Farmers are under pressure to cultivate fields continuously, not allowing time for fallow periods. In addition, the absence of young men, especially during the peak periods in the herding calendar or agricultural cycle, limits flexibility.

What were once coping responses to drought, food insecurity and famine are no longer a temporary response in times of extreme drought or other crises. Instead, they have become a regular feature of dryland livelihoods. Farming and pastoralism as adaptations to environmental variability have been undermined by a wide array of factors, including multiple coinciding shocks, erosion of local governance of natural resources, increasing competition and conflict (discussed below). Meanwhile, additional constraints on production have been added, such as the decreasing fertility of cultivable land and the loss of natural rangelands to cultivation.

Coping responses have serious consequences and implications for the continuity and sustainability of livelihood specialization. The outmigration of young men serves to reduce the labour available within the household and further increase the work burden and time commitments of women in particular, especially in poorer households. It is therefore not only the seasonality of women's workload but also the increasing work burden of women resulting from increasing diversification and the migration of men that has a detrimental effect on childcare and potentially on personal hygiene in the home because of the limited time availability of women and delegation of childcare to others.

Livelihoods and conflict

When reviewing long-term conflict trends in this region, on the one hand, there is a risk of oversimplification and of reinforcing unhelpful stereotypes. On the other hand, there is also a risk of getting lost in the multilayered complexity of wide-ranging conflicts that involve multiple actors and play out at different levels (from the local to the subnational, national and transnational). In the Darfur context, conflict analysis has become a polarized debate. Conflict is viewed as a problem of government oppression and political marginalization versus an alternate view of climate driven by tribal conflict over natural resources (Bromwich, 2017). Within this complexity, the very localized farmer–herder conflicts tend to either become subsumed as part of other recognized conflicts (for example, inter-tribal conflict is frequently seen as an extension of farmer–herder conflict) or may be potentially ignored altogether. The analysis presented here, focusing on livelihood systems from the landscape to the local level, has tried to take a more localized perspective on how conflict has impacted the lives and livelihoods of local communities as reported in their historical timelines. What this reveals is a wide diversity of experience, even amongst the neighbouring communities, that predates the wider Darfur conflict, which started in 2003. The analysis also shows the linkages between local-level farmer–herder conflicts and wider conflicts, which are potentially important for peacebuilding and moving forwards with institutional changes that promote peace.

A further aspect to consider is the symbiotic relationship between farmers and herders. Over past decades, this has been undermined as a result of multiple factors, including changing land-use patterns, economic changes linked with the commoditization of natural resources, and increasing cash needs linked with production and livelihoods in general, as well as demographic, social and political changes.

The seasonality of acute malnutrition

In this section, we will briefly review the literature on child seasonality, how this might have contributed to the current widely held assumptions on seasonality and drivers of the peak of child malnutrition, and implications of the findings of this research. However, first of all, this is not a systematic review of the literature, and second, the wide range of nutritional indicators, methods, definitions of key variables, disciplinary approaches, and so on used in the research makes comparison across studies extremely difficult. Instead, this brief review is intended to help contextualize our research and its relevance within the existing body of seasonality nutrition literature.

The first documented exploration of seasonality and child growth was recorded in the late eighteenth century. Le Comte de Montbeillard measured his son's height every six months between 1759 and 1777.

His data showed that his son grew twice as much in the summer as in the winter (Tanner, 1981). A substantial amount of research and literature followed in the 1930s, coming out of the United Kingdom and North America. Specifically, Orr and Clark (1930) reviewed 12 seasonal growth studies conducted in Europe and the United States.

The majority of the findings suggested that the largest increase in height happened in the spring and that weight gain was greatest in the autumn (Orr and Clark, 1930). Seasonality of growth in the developing world began to be documented in the mid-twentieth century.

Valverde *et al.* (1982) carried out a systematic review of available information on seasonality and nutritional status. The authors found that in most of the literature at that time, when seasonality of nutritional status was identified, occurred in the rainy and pre-harvest months. These months are "usually associated separately with disease incidence and peaks with lower energy and nutrient intake. In most areas of the developing world, however, rainy months with a higher incidence of disease coincide with the lean or hungry pre-harvest months" (Valverde *et al.*, p. 522). However, it is worth noting that of the 16 African studies referenced in the report, 11 were conducted in West Africa (of which 6 came from the Gambia), 2 in Uganda, 1 in Tanzania and 1 in South Africa. Thus, these findings cannot be extrapolated beyond the regions of interest to other climatic zones, such as arid and semi-arid climates as found in the Sahel or Horn of Africa, which exhibit very different environmental and climatic conditions.

Another review of the literature from the 1980s specifically on adult nutrition in the developing world made a similar conclusion: "In most agricultural groups, body weight is maximal shortly after the end of the harvest, while the minimum is 2 to 5 kg less during pre-harvest cultivation. Amongst pastoralists, weight is lowest during the hot, dry season when the milk supply from animals is lowest and activity is high" (Teokul, Payne and Dugdale, 1986, p. 2). The authors defended their focus on adult nutrition by saying that the "importance of season on the health and growth of children is well known" (p. 20) and then referenced the above Orr and Clark (1930) study from the developed world.

More recent available literature is far more geographically diverse, which is similarly reflected in the findings. However, we will limit our discussion to the African continent. Multiple studies identified the rainy season as corresponding to the worst nutritional status for farming populations (Simondon *et al.*, 1993; Chotard *et al.*, 2010; Grellety *et al.*, 2013). However, work coming out of Ethiopia, Chad and Malawi told a slightly different story, with worse nutritional outcomes amongst children in the dry season. For example, a one-year longitudinal study in Ethiopia showed that child undernutrition was higher in the dry season as compared to the wet season (Egata, Berhane and Worku, 2013). More recent research coming out of Ethiopia replicated these findings (Roba *et al.*, 2016).

Another study in Chad with two points of data collection within the year found that the prevalence of GAM was significantly higher at the end of the dry season in relation to the end of the rainy season and that this applied to both nomadic and sedentary communities (Bechir *et al.*, 2010). A study in Malawi, while not following the same households, looked at 12 months of cross-sectional surveys from March 2004 to March 2005 and found that amongst the farming population, children are more likely to be underweight in the dry season.

The authors argue that the seasonal pattern observed is more indicative of childhood illness as a driver of nutrition as opposed to household food availability (Chikhungu and Madise, 2014). However, it is worth noting that both Egata, Berhane and Worku (2013) and Chikhungu and Madise (2014) expressed their surprise at the “contradictory” findings in the paper.

Chikhungu and Madise (2014) wrote, “A *surprising* finding is that children were less likely to be stunted and less likely to be underweight in the lean cropping season compared to the post-harvest season” (p. 1, emphasis added). Egata, Berhane and Worku (2013) noted that

in this research seasonal variations have been observed in the magnitude of acute child under-nutrition, with a relative rise of the condition in the dry season of the study setting...The increase was found to be *inconsistent* with few documented longitudinal evidence from studies conducted in other developing settings (p. 6, emphasis added).

As noted in the introduction of this section, comparisons across studies are difficult to make. For example, the 1980s review by Valverde *et al.* (1982) starts the seasonality review by listing the challenges of the task at hand:

“Season” is defined as a period of the year determining a given event in the life style of a particular community: winter, summer, harvest, non-harvest. The definition of “nutritional status”, particularly malnutrition, is more difficult. A variety of techniques have been used in the last 50 years to assess malnutrition at community and individual levels. These include anthropological non-quantitative studies, food availability studies at the national or community level, evaluation of food consumption and energy and nutrient intakes of families and individuals, energy expenditures, mortality and morbidity rates, cross sectional or longitudinal anthropometry, biochemical tests, and clinical examinations. (p. 522)

In our brief review, we have similarly identified a host of different distinctions in the analysis that, when referenced from paper to paper, frequently lose their nuance. For example, several authors, when writing on the seasonality of child nutrition, reference findings from studies on adults without indicating a distinction. The following were key categorical distinctions across the topic of “nutritional status:”

- Different disciplines (health, nutrition, anthropology) as identified by Valverde *et al.* (1982) above
- Different contexts (climatic and ecological zones)
- Different age cohorts (infants, children, adolescents, adults)
- Different livelihood categorizations (pastoralist, farmer, sedentary, nomadic)
- Different nutritional indices – weight gain, WHZ, HAZ, WAZ, tuberculin skin test by age (TST/age), and mid-upper arm circumference (MUAC).

One particularly critical distinction that we wish to expand on is how the seasons and time period were defined, and hence the value the researchers attach to them. Most nutrition surveys are cross-sectional, meaning they represent a snapshot in time, and will fail to reflect seasonal differences unless other time periods are considered. Unfortunately, much of the research on the seasonality of nutritional status took a rather binary focus: rainy vs dry season or pre-harvest vs post-harvest, with only a few studies focused on more frequent observations (Chotard *et al.* 2010; Grellety *et al.*, 2013; Chikhungu and Madise, 2014). Even when data were collected monthly in one study, the authors aggregated it to be binary.⁵

An important implication of this binary view of seasonality is that this dominant narrative regarding the key seasonal periods for child nutritional status is built into the design, making drawing more nuanced conclusions impossible.

While difficult to say directly, a likely consequence of the generalization of findings across age groups (i.e. from adults to children) and ecological zones, and the predominance of research from West Africa and the Gambia more specifically, is that it has led to embedded assumptions and narratives of the seasonality and drivers of acute malnutrition. A widely held assumption is that the peak of child acute malnutrition coincides with the “lean,” “hunger” or “rainy” season because of food insecurity before the harvest. For example, Vaitla, Devereux and Swan (2009) write, “Most of the world's acute hunger and undernutrition occurs not in conflicts and natural disasters but in the annual ‘hunger season,’ the time of year when the previous year’s harvest stocks have dwindled, food prices are high, and jobs are scarce” (p. 1). One leading nutrition NGO wrote in 2013, “This period is commonly known as the ‘lean’ season, or hunger period, when many households are teetering on the edge of food insecurity, and usually coincides with the rainy season, when disease strikes hardest. The end result is seasonal peaks in acute malnutrition” (ACF International, 2013, p. 4). The underlying assumption here is that food insecurity is the main driver of acute malnutrition and hence is a determinant of seasonal patterns in acute malnutrition. In the report entitled “The state of food security and nutrition in the world,” FAO *et al.* (2018) recognize that “[e]stimates of wasting prevalence can vary across seasons” (p. 20) but go on to explain, “They are commonly at their highest during the rainy season, often coinciding with the pre-harvest period and thus with food scarcity as well as higher rates of diseases including diarrhea and malaria” (p. 21). This assumption of seasonality has held dominance over the past three decades.

Several studies of pastoralist nutrition in the literature report the dry season and late dry season as the most critical period for nutritional status of pastoralist adults and children (Loutan and Lamotte, 1984; Benefice and Chevassus-Agnes, 1985; Hilderbrand *et al.*, 1985; Bechir *et al.*, 2010). One of the earliest studies, in Niger amongst Wodaabe herders, reported weight losses amongst men and women, and a failure to gain weight and weight loss amongst children, from February to May (the dry season; Loutan and Lamotte, 1984). Several stress factors were identified

⁵ “Seasonality was examined for unpaired (all children) and paired (children measured in both seasons) samples in two contrasting times of the year, February (late winter) and August (monsoon), and levels of statistical significance ascertained using a Wilcoxon matched-pairs test for repeated measures. Month-by-month changes in weight and height velocities were then examined for a subsample of children measured in all the months of observation” (Panter-Brick, 1997, pg 4).

during this season similar to those noted by Darfuri focus groups of women, including the least milk available, limited supplies of water at a time when needs increase because of the heat, increase in water-carrying work and distances travelled to collect water, and peak work levels (Young and Marshak, 2018). Back in 1993, Simondon *et al.* wrote that

the critical period during which nutritional status is impaired generally occurs around the end of the rainy season for farmers and around the end of the dry season for pastoralists. In both cases, the determinant invoked is concomitance of increased physical activity in adults and seasonal food shortages (p. 166).

The dominance of the lean season assumption has huge implications for scheduling surveys and programming.

For example, the 2018 call to action by the early warning system used across the Sahel wrote, “This year’s especially acute lean season is approaching its peak – meaning food scarcity, increasing severe acute malnutrition and outbreaks of epidemics” (CILLS, 2018, p. 1).

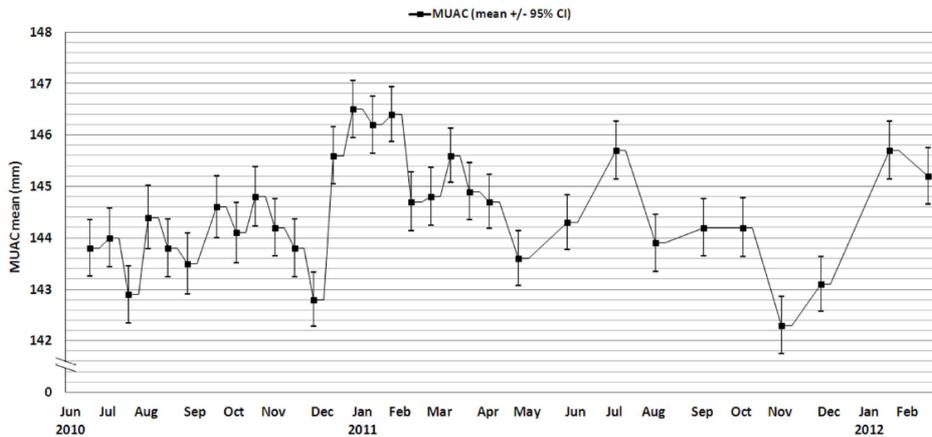
Our own analysis of SMART surveys in Chad, the Sudan and South Sudan, alongside a few studies referenced here, questions the dominance of this assumption. Our research identifies both the end of the dry season and the end of the rainy season as periods of vulnerability, with higher prevalence of wasting at the end of the dry season, and then a surprising improvement before that second peak at the end of the rainy season. These “twin peaks” highlight the role of multiple factors beyond, but also including, food insecurity that might be more prominent at the start of the rains or end of the dry season. These factors need to be given equal weight and consideration when mapping drivers of acute malnutrition. While our study only focuses on seven regions across three countries, geographically clustered, the implications are possibly applicable across dryland environments, which make up 40 percent of the world’s total land area, 43 percent in Africa and 39 percent in Asia, including Russia (FAO, 2008).

However, it is also important to consider the localized variation in these trends. While our analysis identifies similar seasonal patterns, it also shows varying, but significant, relationship between the climatic factors and child acute malnutrition across the three country case studies. While our data do not allow it, a more regional analysis with consideration for different livelihood specializations might uncover even greater heterogeneity in seasonal patterns and risks. To our knowledge, few studies consider this level of complexity and variability. However, without these considerations, there is a danger of over-dependence on untested assumptions.

An important final consideration is that we cannot presume that identified trends in seasonality are constant over both the short and long term. Most likely seasonality patterns change as different drivers become more or less important. For example, in famine conditions, while both peaks might persist in our three country case studies, the secondary peak might grow in size and importance. The analysis conducted by Grellety *et al.* (2013) identifies the peak of child wasting (using MUAC) at the end of the rainy season. However, for the monthly MUAC values in 2010, MUAC appears lower at the start of the rains (July 2010) and then

improves before falling again at the end of the rains (September 2010; Figure 20). In 2011, MUAC again falls during the dry season, only to improve slightly before hitting its low during the harvest (November 2011). It is worth noting that 2011 was one of the most food-insecure years in the Sahel and Horn of Africa in the past decade.

Figure 20. MUAC mean of children aged 6 to 59 months in Northern Nigeria



Source: Grellety *et al.*, 2013.

The magnitude of seasonality could be linked with other factors as well. For example, while we observe seasonal patterns and relationships between environmental and nutritional variables, the relationship is much weaker in South Sudan. While the weaker relationship could be an artifice of the data, it could also point to the role of protracted conflict, which might elevate the year-round base levels of acute malnutrition while maintaining the seasonal peaks and troughs or alternatively, might dampen the expected seasonal improvements during certain times of the year. Poverty and development also play an important role and are likely reflected in the higher magnitude of seasonality in Chad versus the Sudan. Despite similarities in climate and culture, Chad remains significantly poorer and less developed than its western neighbor. For example, Nabwera *et al.* (2017), using routine growth data from 1976 to 2012 in the Gambia, have found a decline over time in seasonal variability, which the authors attribute to general improvements in the country, such as increased wealth (Nabwera *et al.*, 2017).

Our analysis further underscores how critical, and yet frequently neglected, considerations of seasonality are in addressing acute malnutrition. While GAM is considered an emergency indicator, the combined regression analysis shows that over the long term, environmental variation – particularly temperature and vegetation and their within-year variability – is an important consideration alongside disaster and conflict events. Thus, a better understanding of the seasonal drivers of acute malnutrition could help explain the persistence of wasting in non-emergency years despite the constant presence and investment by humanitarian and development actors (Young and Marshak, 2018).

Implications for methodology

Several key methodological considerations emerge from our own analysis and the review of the literature: the timing and frequency of data collection; the assumption of causality; and the limitation of experimental approaches such as randomized controlled trials (RCT).

For variables that are characterized by extreme within-year variability, surveys that provide only one annual snapshot, such as cross-sectional surveys, risk minimizing our understanding of that variable and its drivers.

Both our own analysis and existing research that draws on longitudinal data, multiple within-year observations (though not necessarily following the same household or children), or aggregation across multiple cross-sectional surveys (Maxwell and Burns, 2008; Chikhumgu and Madise, 2014; McDowell, 2008) are better placed to capture the within-year variability. Application of these methodological approaches is critical because understanding the timing of the peaks of acute malnutrition gives insight into the season-specific drivers and allows the nutrition community to better target the timing and content of their programming depending on the season.

Without a context-specific understanding of seasonality, and its potential variation between years when facing either large, repeated/persistent shocks or a combination of covariate shocks, it is too easy to fall back on the “food first” assumption linking acute malnutrition strictly to food insecurity. This assumption implies a clear causal link; however, while food insecurity is an important driver of acute malnutrition, it is not the only one driving seasonality.

Finally, the current emphasis on experimental methodologies (such as RCTs) has emerged as the main way to evaluate and address problems in the development sector. However, experimental studies have not eliminated accusations of uncertainty but rather have limited the credibility of non-experimental design (Donovan, 2018). RCTs are only able to confirm if a specific programme in this specific context works when adopted by the recipient community or households. And while that is a powerful tool, unless we first have identified the risks based on the holistic and contextualized formative research structure, RCTs on their own are not enough.

Implications for future research, programming and policy

The findings in our report have specific implications for nutrition programmes, policies and practices.

Methodological implications

A first step to improving our understanding of seasonality and putting in place appropriate programming and policy is for our data collection to reflect the observed variability in a context-specific and holistic approach.

First, we need to prioritize more exploratory and formative research, with a focus on mixed methods. Such an approach would allow for the construction of a better explanatory framework that considers the seasonality of possible drivers (livelihoods, gender roles, social relations, conflict), local perspectives, and environmental analysis (remote-sensing data). While this might sound like a tall order, analysis of these factors, when done well, provides a solid foundation upon which to build. In other words, the historical context has not fundamentally changed; conclusions drawn from past scholars remain valid. However, these are frequently ignored, especially in the annual humanitarian needs assessments, which treat each emergency as year zero and ignore much of the wider body of knowledge that is currently available on the context. Available secondary data, as evidenced by this report, can go a long way in laying the foundations for a more context- and time-specific explanatory framework.

Second, accepting the importance of seasonality implies greater emphasis on the need for longitudinal data collection, with specific consideration of local understandings of seasons. For example, in Darfur, communities identified five different seasons, each associated with different environmental conditions and livelihood opportunities and constraints, which in turn can affect child and household well-being. While we are not suggesting that every survey needs five points of data collection, it is important to move beyond the binary understanding of harvest vs non-harvest or rainy vs dry season, which is more about our assumptions than a reflection of the reality on the ground. Furthermore, within-year environmental variability means that we cannot necessarily substitute a month for a season, as the variability in the timing of the rains, and hence of livelihood activities, can be huge (up to two months) in the Sahel. And while we cannot necessarily wait for certain environmental factors to start a survey, we can use available and free remote-sensing data to put our findings in the context of those environmental factors. Identifying appropriate time periods for longitudinal data collection can be partially achieved through more holistic formative research, as advised under the first recommendation.

Third, while it is useful to generalize across contexts and time, there is a real danger of accepting assumptions that have not been verified for the region and time period of concern. For example, Grellety *et al.* (2013), using two years of monthly observations on the same communities, show slightly different peaks in 2010 vs 2011, possibly related to the 2011 food security crisis. Similarly, our own analysis, while confirming twin peaks across three country contexts, still shows contextual differences, with a much smoother curve in South Sudan, possibly related to the role of protracted conflict.

Thus, we recommend that projects in areas without a history of primary data collection do not necessarily extrapolate from other contexts without being able to at least partially verify the assumption with primary data collection or secondary data analysis.

Research considerations

The methodological considerations listed above also apply to research. In this section, we specifically focus on research topics and the incorporation of seasonality across research carried out in dryland environments.

While there have been improvements in the prevalence of stunting over the past two decades, wasting has remained fairly steady, with some evidence of increase (Nabwera *et al.*, 2017). The three country case studies covered in this report – Chad, the Sudan, South Sudan – suffer from persistently high levels of acute malnutrition even in regions and time periods that are free of humanitarian disasters. We recommend a review of available secondary data to establish the seasonal trends in acute malnutrition in contexts where the prevalence of wasting remains high and has not shown a considerable decline over the past decade. In addition, seasonal trends in child stunting, underweight, as well as adult malnutrition, should be reviewed.

Seasonality should be integrated as a key component of nutritional analysis in dryland environments, along with a recognition that drivers of acute malnutrition likely vary by season. The twin peaks observed in Chad, the Sudan and South Sudan likely indicate that what causes acute malnutrition at the end of the dry season is different from what causes acute malnutrition prior to the start of the harvest. Thus, cross-sectional analysis can incorrectly identify lack of significance of one contributor purely due to the timing of the survey. Incorporating seasonality into research means accepting the assumption that at different times of the year, households and survey results will identify different conditions that contribute to malnutrition. Working on this assumption will provide a much more accurate and nuanced understanding of what causes acute malnutrition. One expansion on this point would be to ask the question, “If drivers are different at different times of the year, are different subgroups of the population affected differently?” We already know this is true for pastoralists vs farmers, but perhaps other community-, household- or child-level characteristics could be identified as particularly vulnerable depending on the season, hence increasing the efficacy of targeting. A review of seasonality could be integrated as a systematic goal of SMART surveys and/or carried out along with an amended Link Nutrition Causal Analysis (Link NCA).

Finally, and we touch on this throughout the recommendations, we need to continue to expand our use of remote-sensing data and their relationship to nutrition indicators. In dryland environments like the Sahel, precipitation and temperature continue to be critical factors influencing livelihood decision-making, which in turn critically influences the underlying causes of malnutrition and nutritional outcomes. Thus, we should aim to incorporate climatic and environmental variables into our analysis in order to increase our contextual understanding of the temporal and spatial distribution of resources, and their relationship with livelihood systems and drivers of malnutrition (as we have done in this study).

Programme considerations

The findings from this report have implications for programme design, especially in relation to the three country case studies and other dryland regions.

The resurgence of the importance of multisectoral programming to address child malnutrition over the past decade has been a positive development and has generated some promising findings (Marshak, Young and Radday, 2016). However, multisectoral programming should not result in a new package of technical interventions or “fixes” without first understanding the complexity of nutrition in relation to social systems (Ljungqvist and Jonsson, 2015). We would add to that the importance of considering the seasonality of nutrition outcomes and its drivers, especially in dryland environments where climate extremes and unpredictability are the norm. Seasonality is already a major programme issue in relation to farming, given the agricultural calendar. A similar approach needs to be applied in addressing the drivers of acute malnutrition. The observation of twin peaks of acute malnutrition, with a clear improvement during the duration of the rainy season, indicates the role of different drivers at different times of year. Thus, programmes need to consider what drives acute malnutrition and when. For example, if contamination of the water source due to increased pressure on water resources by wild animals and livestock is an increasing problem as the dry season progresses, then this is the time to consider the additional support of water resource management for both people and livestock. Borehole utilization is highly seasonal, with much greater use in the dry season, and with subsequent problems of overcrowding and overgrazing in the vicinity of permanent water points. Therefore, programming and maintenance needs to follow a similar calendar to be effective, while a focus on household food security and malaria prevention should occur during the rainy season.

The seasonal timing of programmes intended to reduce child malnutrition needs to align itself with the seasonal livelihood challenges that have a knock-on effect on the underlying causes of malnutrition. For example, an increasing work burden for women associated with increasing diversification could lead to relegating childcare to less experienced individuals, such as older children. Pressures on livelihoods and coping strategies could be leading indirectly to the persistence of wasting and seasonal peaks observed in Chad, the Sudan and South Sudan. Many of the behaviors associated with child malnutrition are not due to negligence but are rooted in the delicate balance of decision-making that households make to deal with the variability of their livelihoods in difficult and changing environments.

It is also important to consider the changing needs as specialist producers diversify, for example, pastoralists into farming and farmers into investing in livestock, and how this affects their livelihood goals and needs for services. Clearly, the specialist farmer will have different goals and needs compared, say, to the nomadic woman only recently engaging in farming. Thus, agricultural interventions need to be tailored and targeted according to the livelihood specialization, even if they share the same geographical space and appear on the outside to be carrying out the same activities. Despite the observed similarity, the requirements of the specialist producer are very different from the newcomer to a specific practice (such as nomadic women starting to farm).

Pastoralism and other dryland livelihood specializations have evolved adaptive management strategies in response to environmental variability, such as pastoralist strategic mobility and the strategies farmers employ when rains are delayed or there are dry spells. Yet both farmers and pastoralists are facing increasing pressures because of externalities beyond their control, such as changing land-use patterns that limit access to natural resources, the commoditization of natural resources, and increasingly complex and protracted conflicts. In response to these pressures, as producers are forced to diversify, they risk engaging in more damaging short-term coping responses. This calls for programme support for the continuity of positive livelihood adaptations (specializations), while addressing short-term, more damaging coping responses.

Gender roles and responsibilities within the specialization and in relation to response strategies are a critical concern. For example, as described in this report, many pastoralists have split households where the women maintain the homestead, often in order to farm, undertake other livelihood activities, and access basic services, while the men seasonally migrate with the herds. Similarly, labour migration, particularly of young men, has resulted in more and more households in which the burden on women has significantly increased. This increasing but seasonal workload of women, which likely varies by household livelihood specialization, in turn impacts a women's availability for child care or hygiene behaviours. In Chad, for example, women can spend the full duration of the planting season living in the fields if there is insufficient male labour or ability to procure a closer field. Thus, any programming to provide clean water to the communities is irrelevant at that time of year. These dynamics are critical for informing a more adaptive learning approach to programme design. Such an approach requires monitoring systems or action research that can guide ongoing programme decision-making throughout the course of the whole intervention (Ljungqvist and Jonsson, 2015).

Policy considerations

There are two main policy-related issues raised by the report findings.

First, the role and importance of environmental variability and seasonality in drylands need to be deeply ingrained into dryland programmatic and research thinking from the start. There is no better way to do that than to incorporate environmental variability and seasonality as part of the basic or more systemic causes within the UNICEF Causes of Malnutrition Framework (Unicef, 1990). Incorporating seasonality as a central pillar of the UNICEF framework would introduce a long-missing temporal dimension and therefore greater depth and nuance.

Considerations for seasonality would underscore that while we need to consider all the potential drivers of acute malnutrition, they might not necessarily coincide nor be relevant at the same time and for the same households, introducing a greater understanding of complexity and potentially complex systems. This would also call for a greater focus on learning through both formative research prior to programme design as well as on ongoing monitoring or action research.

Second, the treatment of malnutrition lends itself to a package of technical interventions or “fixes.” However, the same approach is inappropriate for nutrition-sensitive programmes, as they need to be designed on a case-by-case basis according to the dominant drivers of malnutrition and their seasonality, which ultimately are linked to livelihood systems. For example, research from Chad highlights that increasing pressure on water resources during the dry season by both animals and humans could contribute to increased contamination and child acute malnutrition (Marshak, Young and Radday, 2016). Construction of boreholes to increase access to clean water in this context must also consider the watering needs of livestock, the possible effects of those boreholes on livestock density in these communities, the timing of access to boreholes for women, and/or the effects of the boreholes on community dynamics and power struggles. These considerations illustrate the complexity of planning sustainable nutrition-sensitive interventions and, if ignored, are likely to undermine the initial goal of improving nutritional status.

Conclusions

This study offers clear examples and several lessons in relation to dryland livelihood adaptation and transformation, natural resource conflict and the persistence of GAM, all of which require greater recognition and understanding of environmental variability and seasonality.

Three major blind spots in our collective knowledge have been revealed.

The first of these blind spots concerns the seasonal patterns of acute malnutrition in Chad, the Sudan and South Sudan. Acute malnutrition in these countries shows a remarkably similar pattern of twin peaks that contradicts the widely held assumption that the peak of acute malnutrition occurs during the hunger gap or lean season. The available evidence suggests that twin seasonal peaks in acute malnutrition amongst children linked with a population-wide decline in nutritional status are typical of these populations, although conflict-affected areas are consistently worse. The evidence also suggests that despite the long history of international humanitarian action in these regions, current approaches are failing to either recognize or sustainably address these twin peaks. Standard solutions and packages will only work partially and temporarily (Ljungqvist and Jonsson, 2015). We would argue what is needed is a more participatory and adaptive programming approach, one that is based on a shared understanding of the drivers of malnutrition, that is contextually relevant, and that informs actions at every level. This new evidence provides a hitherto unequalled opportunity for raising awareness about this critical seasonal aspect of persistent GAM and for tailoring investigations that are both more collaborative and participatory into the livelihood constraints and drivers of malnutrition and, in turn, the means to address them. These findings have a much wider significance given that the problem of persistent acute malnutrition in dryland contexts is widespread and is likely linked to both environmental variability and conflict.

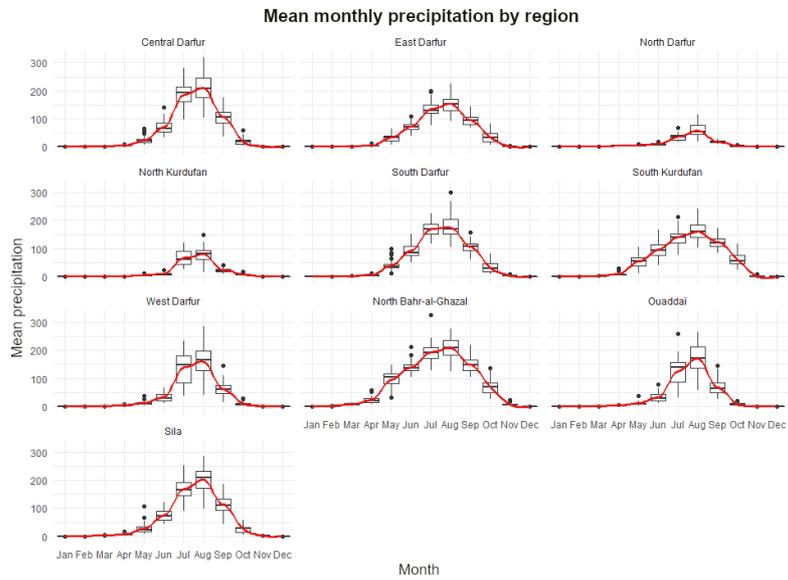
A second potential blind spot in our understanding is farmer–herder conflict, which is reportedly increasing across the Sahel. This form of conflict is often not well understood and is sometimes confused with tribal or cross-border conflicts. Clearly, there are links between the multiple layers of conflict, from the local-level conflicts between farmers and herders to the tribal conflicts and higher-level civil conflicts. Each has its own institutions and mechanisms to mitigate conflict and build peace. However, for a more lasting peace, there needs to be a deeper understanding of the potential linkages between conflicts and implications.

A third blind spot is that most measures of resilience fail to take adequate consideration of the shocks themselves, focusing instead on the risks, vulnerabilities and resilience of systems. This work has shown the importance of the history of shocks, how wide ranging they are, and how communities adapt or cope with different types of shocks. From both a community perspective and our more quantitative analysis, the impact of conflict was shown to far exceed drought and other shocks. Greater consideration of community perspectives on climate, conflict and other shocks would provide a more in-depth and accurate understanding of the localized impact and deeper effects on livelihood specializations and their integration as part of a wider system.

A final important lesson from this paper is the need to prioritize deepening an evidence based understanding among stakeholders, based on the most recent and accepted body of knowledge. Only then can we begin to jointly identify and challenge outdated thinking, old paradigms and wrong assumptions. Unless this learning is prioritized, the gaps between research, policy and practice are likely to widen to the further detriment of dryland communities. A pragmatic strategy and a new approach for engaging with stakeholders is called for; one that values local perspectives, and contextual and specialist knowledge and experience as crucially evidential.

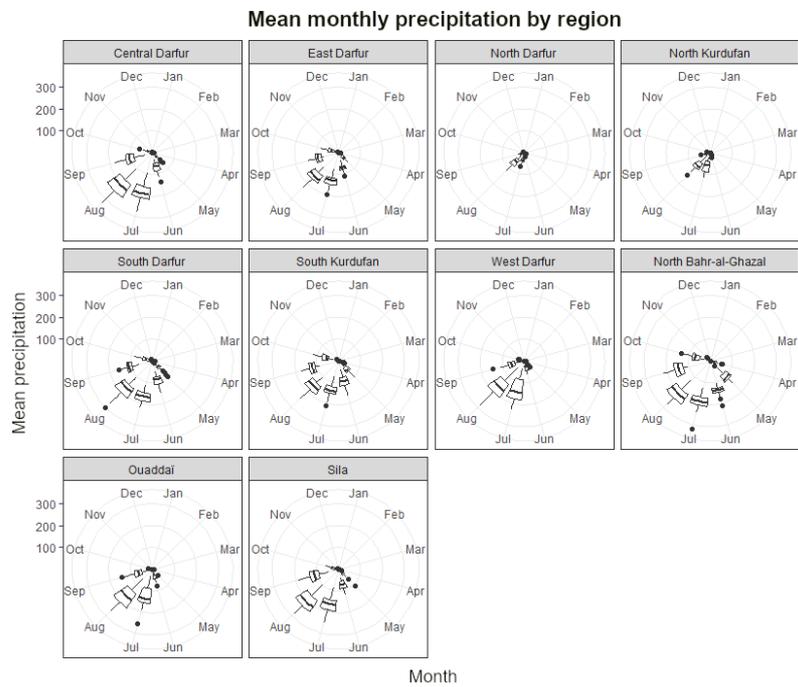
Annex

Figure 20. Mean monthly precipitation by region, 1980–2018



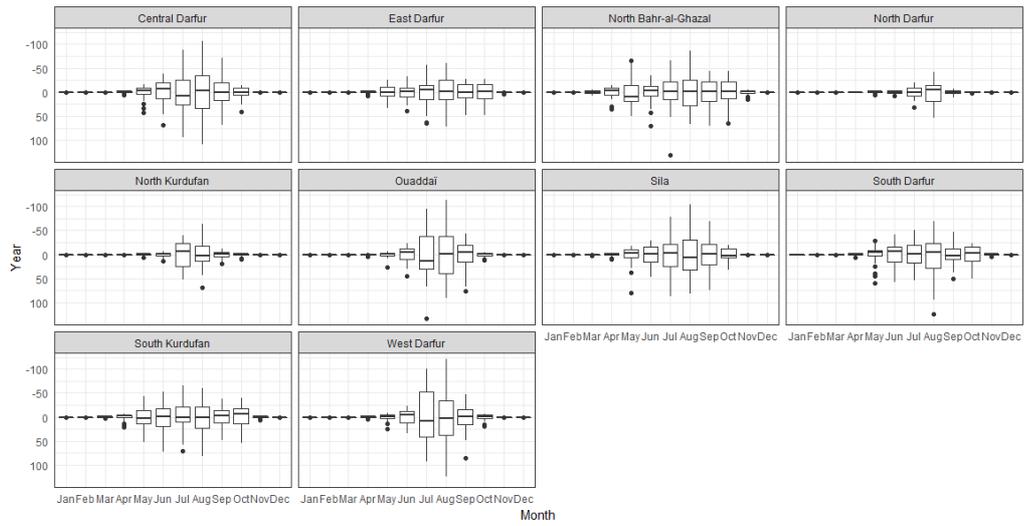
Source: Feinstein International Center, 2019.

Figure 21. Mean monthly precipitation by region, 1980–2018



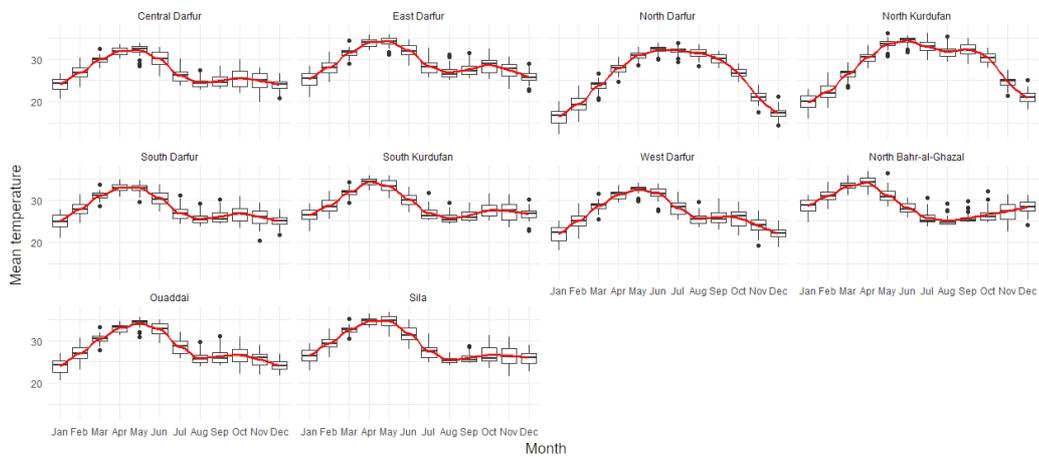
Source: Feinstein International Center, 2019.

Figure 22. Variability of mean annual precipitation by region, 1980–2018



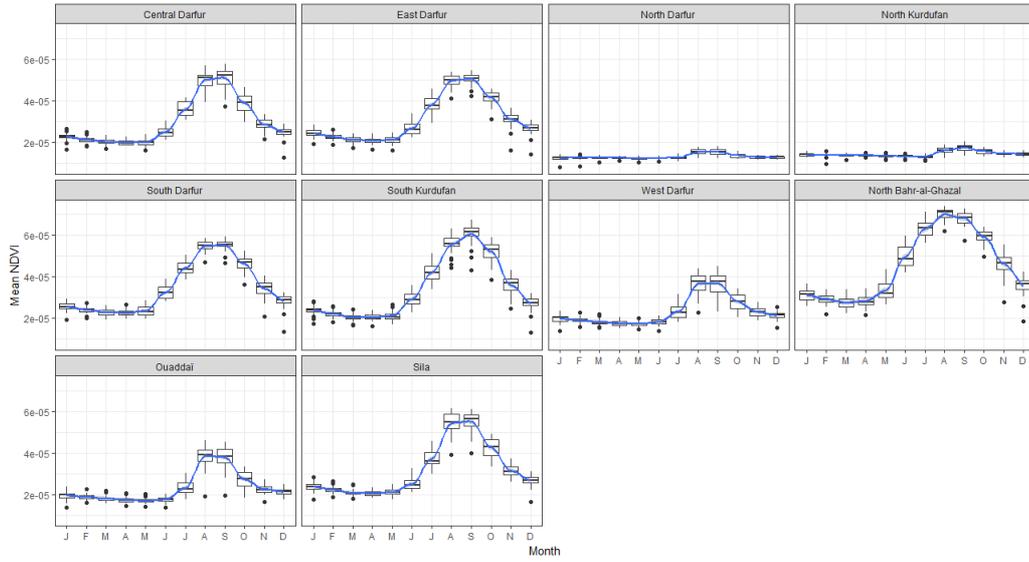
Source: Feinstein International Center, 2019.

Figure 23. Mean temperature by region, 1980–2018



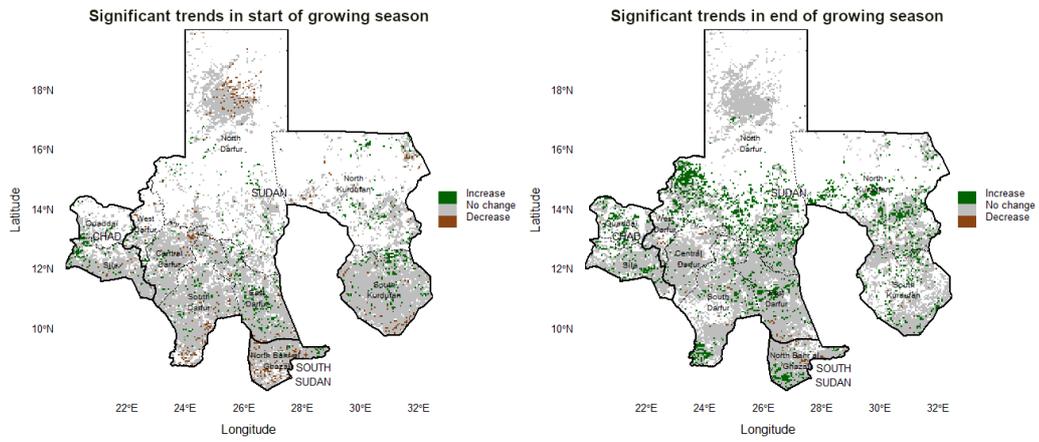
Source: Feinstein International Center, 2019.

Figure 24. Mean NDVI by region, 1980–2014



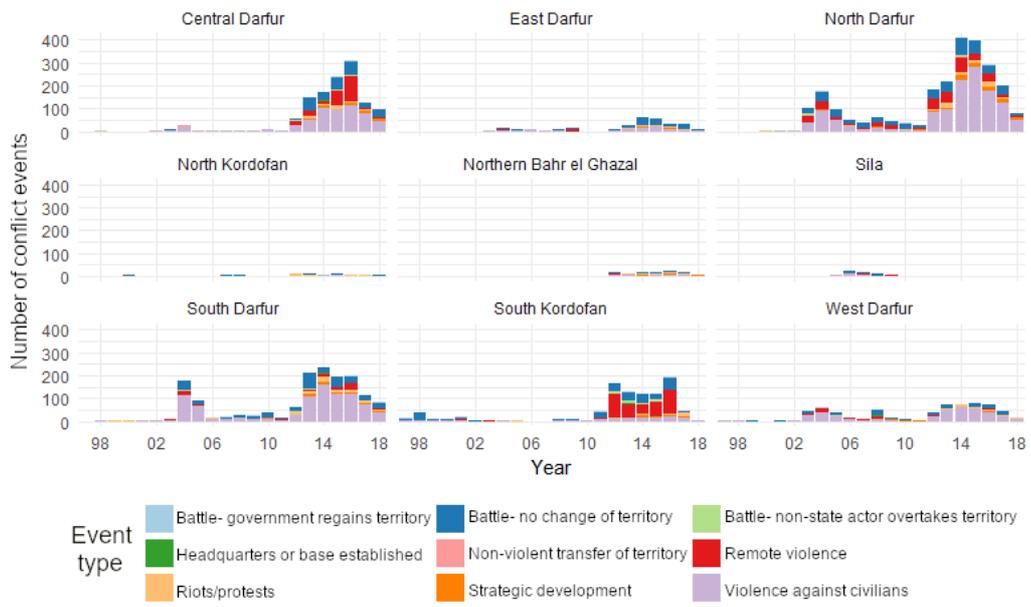
Source: Feinstein International Center, 2019.

Figure 25. Significant trends in start and end of growing seasons. Increase indicates later start/end; decrease indicates earlier start/end



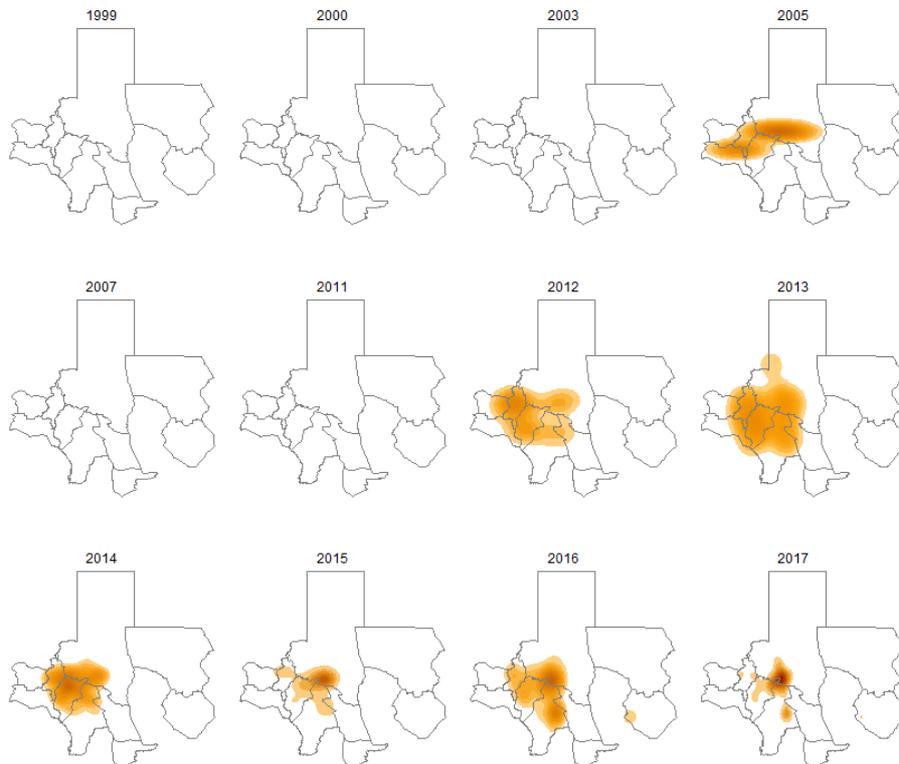
Source: Feinstein International Center, 2019.

Figure 26. Types of conflict by region over time



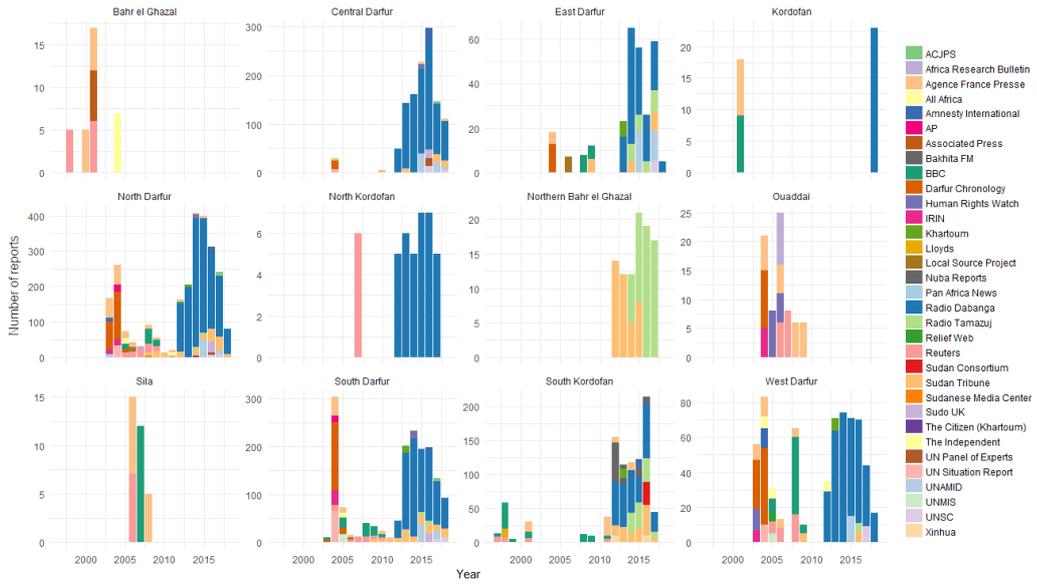
Source: Feinstein International Center, 2019.

Figure 27. Distribution of farmer–herder conflicts by year in the regions of interest



Source: Feinstein International Center, 2019.

Figure 28. Distribution of media sources in ACLED



Source: Feinstein International Center, 2019.

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Saving livelihoods saves lives

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